THE

Journal of the Society of Arts,

AND OF

THE INSTITUTIONS IN UNION.

110TH SESSION.] FRIDAY, MAY 6, 1864. [No. 598. VOL. XII.

Announcements by the Council.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock.

MAY 11th.—"On the Economy of Agricultural Cottages, considered with regard to the interests, the position, and the duties of the labourer, the tenant-farmer, and the landowner." By J. BAILEY DENTON, Esq.

LABOURERS' COTTAGES.—DENTON PRIZES.

The following is the report of the Judges appointed to decide on the competition for Prizes for designs of cottages for the labouring classes, offered by J. B. Denton, Esq., through the Society:—

TO THE COUNCIL OF THE SOCIETY OF ARTS.

London, April 20th, 1864.

GENTLEMEN,

After a careful consideration of the Designs submitted to us, numbering in all 134, from 107 competitors, residing in all parts of the United Kingdom, we feel it incumbent on us to offer a few remarks in explanation of our decision.

We would observe, in the first place, that although the terms of the competition are such as to limit our attention rather to small matters of detail, affecting the stated cost, than to permit our actually selecting the best design which could be built for a reasonable outlay, we have given our consideration to the whole subject of cottage accommodation for the labouring classes.

Notwithstanding that the offer of these prizes has been the means of procuring so large a number of Designs, we cannot but consider that no satisfactory solution of the problem proposed has been given. The possibility of erecting really good and substantial cottages for the labouring population of this country generally, with the stated accommodation, at a cost not exceeding £200 a pair, all profits and expenses included, is not demonstrated by the present designs. This is shown by the remarks of the competitors themselves and by the shifts they have found themselves obliged to adopt in order to reduce the cost, as well as by those exceptional cases where, owing to some peculiarly favourable circumstances, or by omitting some feature not so important in one locality as in another, a result somewhat approaching that which is desired in the cost has been arrived at, not in any case, however, without contravening the terms of the competition in reducing the given prices of certain items.

We particularly mention good and substantial cottages of the given dimensions, for it is to such alone that our attention has been directed, as it cannot be the desire of the donor of the prize or the wish of the Society of Arts to encourage the erection of cottages of an inferior character. We have in all cases taken the cost of cottages to be erected in pairs, it being obvious that a better building can be provided for a stated sum when attached to a similar one, and thus the cost of some of the walls, roofs, &c., divided between the two. On the other hand, the cost of a row of ten pairs of cottages can hardly be taken as a fair criterion of the value of a single pair, a group generally much more frequent and desirable than the larger number.

Several items are included in the terms of the competition which we think should have been more clearly defined or excluded altogether from the estimate, for it is obvious that the words "water supply, well, fencing, paving, &c.," may be taken to imply very different items of expenditure by different individuals in a competition. Again, while brickwork as a material for walls of cottages is almost unknown in some parts of the country, it is obvious that rubble walling must be reduced to value in the terms of brickwork to get at a fair comparison of the cost according to the terms of the competition, and similarly roofing, if of tiles, must be valued as slates at the given price.

The paragraph referring to the height of rooms seems to have been differently understood by the competitors, the word "clear," at the end of the sentence relating to this matter, having been taken by some to mean the height of the ground-floor up to the ceiling, while the generality of designs allow only nine feet, including the thickness of ceiling, upper floor joists, and flooring.

It is true that in some parts of England, where bricks can be obtained at from 18s. to 20s. a thousand on the spot, and where certain facilities exist for obtaining other materials, where timber is inexpensive and concrete foundations are scarcely required, a certain kind of cottage may possibly be erected for the sum named in the instructions (though generally speaking it is not so), but it would be highly improper, without the addition of considerable improvements, at increased cost, to recommend such cottages as fit to be erected for the occupation of the labouring classes generally.

Of all the plans submitted, therefore, none can be said strictly to conform to the terms of the competition, both as to the accommodation required and the cost. To none, therefore, can we, strictly speaking, award the prize. We, however, deem the design marked by you as No. 23 to be, on the whole, the one most conformable to the terms of the instructions, as well as to the proper requirements and conveniences of a labourer's cottage, and, therefore, we recommend that the prize of £25, open to the United Kingdom, be awarded to this design.

It must be understood as our opinion, however, that, generally speaking, brickwork of 9 inches thick for outer walls in exposed situations is not sufficient to resist the weather, and therefore we should recommend some system of hollow walls to be adopted, which would of course add to the cost. With reference to this we would call attention to the remarks of a competitor (No. 71), to which we quite assent. He proposes to build the cottages shown in his design in nine-inch solid brickwork, the stipulated cost not allowing him to make them of greater thickness, and adds "Should it be thought advisable to increase the expenditure for this purpose he would recommend hollow walls built in brickwork, the space between being 2½ inches, and the walls bonded together with wrought-iron ties."

It is only fair to observe that several other competitors (as Nos. 2, 14, 30, 81, and others) show various systems of hollow walling, or some kind of hollow bricks.

Though not specially mentioned in the instructions, an oven is, we consider, often a matter of importance, and if made common to both cottages (as in Design No. 71) may be added without any great expense.

We cannot recommend the ordinary water-closet apparatus with cistern pipes, &c.—so liable to get out of order—for general adoption in ordinary labourers' cottages. A modification of this by the use of a common syphon pan, with the ordinary privy or cesspool, will be found sufficient; and when, by means of ashes, clay, or other deodorising substances thrown into the pit, the loss of the soil is prevented, the matter is not unimportant.

The use of cast-iron casements, as in Design No. 23, is not desirable, owing to the difficulty of making and keeping them water-tight, their liability to fracture, and the difficulty of repairing them. We should recommend sashes or casements in wooden frames, and no lead lights for other than ornamental purposes.

The internal walls of some of these designs are not plastered, thus evincing an attempt to save cost. Perhaps, in some cases, with very good bricks and in certain localities, plastering may not be required, but generally speaking it is desirable to plaster the bedrooms and living rooms of cottages.

In some of the designs the living room floors are described to be common flat brick paving. Good paving tiles at least should be used, but we consider wooden floors, for the living room as well as the bedrooms, generally indispensable to the comfort of the inhabitants.

The Design No. 23 shows well-ventilated pantries and good coal-stores; also a well, common to both cottages, and a rain-water butt.

The partitions shown in some designs (particularly No. 71) in the upper floors, of ¾-inch boarding only, are not sufficient except, perhaps, next the staircase. The separation between the rooms should be of a more substantial character.

Design No. 23, to which we award the chief place, would be greatly improved by dormers over the upper windows at the back, so as to give greater space for light and air to, as well as to improve the appearance of, the cottage.

In all cases when the sloping parts of slate roofs especially (and generally also of tile roofs) are made a portion of the ceiling of the upper rooms some plan should be adopted to check the access of heat and cold.

It is stated that cottages of the same design as No. 31 are being erected in large numbers in Yorkshire at a cost within the amount stated in the terms of the competition; but we find in the estimate that the brickwork is taken at £6 a rod instead of £8, as in the instructions, and other work at proportionately low prices.

With regard to the prize offered specially to the members of the Architectural Association, the number of designs sent in is small in comparison, and we regret to observe that the attempt to conform strictly to the terms of the competition as to cost, seems to have led to the sacrifice of essential conveniences and comforts, although there is no design which we can say has successfully met the instructions even in this respect. Either in substituting tiling at a flat pitch for slates, or by reducing the heights of some rooms, or placing the water closet inside the walls of the house, or in some other way, attempts have been made to meet the instructions, which only serve to preclude the possibility of our recommending any of the designs submitted for the prize, or of according to them our commendation as generally fit to be adopted as dwellings for labourers, without a variety of improvements.

We would observe, however, that No. 15 offers a suggestion deserving of remark, as it submits a plan with one of the bed-rooms on the ground-floor, whereby the size of the upper rooms is increased and the boys and girls of the family are more completely separated. Only one door to the house is provided, and the scullery is reduced in size. This plan obviates in a measure the difficulty arising from the area required for the upper floor of a cottage with three bed-rooms on that floor generally exceeding the area actually required on the floor below. Such an arrangement as this may be desirable in some localities, but it is not contemplated in the instructions. This design is shown as roofed only with pantiles at a low pitch. The general plan of No. 29 is, upon the whole, good, but the elevation as shown cannot be commended, unless the improved elevations, as sketched in the alternative design, were adopted, which would then bring the cost considerably beyond the stated sum.

In fine we may observe that although good cottages may possibly be erected, under favourable circumstances, in some parts of England for a lower sum, we consider the probable average cost of a pair of cottages built with the conveniences we have enumerated would be about £280 to £300, and that the attempt to erect them at any considerable reduction upon this amount must result in some inferior kind of buildings, discreditable to the owner, and wanting in much of the necessary accommodation for a labourer and his family.

We would further remark, in conclusion, that there are other advantages besides the mere per centage on the outlay which must be looked for to remunerate a cottage builder for his expenditure on improved dwellings, advantages nevertheless capable of being estimated at a pecuniary value, such as proximity of the labourer to his work and consequent saving of time, &c., amounting often to quite as much cash value as half the rent of the cottage, but especially the moral and physical welfare of the tenants, and the proper sanitary condition of their dwellings. These latter considerations, after all, are those which give so great an importance to the subject, and which have prompted us to give especial attention and care in deciding what may at first sight seem but a simple matter.

We are, Gentlemen,

Yours obediently,

CHAS. FORSTER HAYWARD, Architect.
GEO. DINES, Builder.
JOHN CLUTTON, Land Agent.

The name of the successful competitor (No. 23) is Mr. John Birch, 51, Holywell-street, Westminster, to whom the Council have awarded Mr. Denton's prize of £25 and the Society's silver medal, in accordance with the recommendation of the Judges.

Examinations.—Government Appointments.

Mr. George M. Norris, of the City of London College, a Prizeman at the Society's Examinations last year, who was nominated by the Council to compete for an Assistant Clerkship in the Privy Council-office, has been successful in the Examination recently held by the Civil Service Commissioners, and will receive an appointment. The nomination was kindly placed at the disposal of the Council by Earl Granville.

Proceedings of the Society.

Twentieth Ordinary Meeting.

Wednesday, May 4th, 1864; Admiral Sir Edward Belcher in the chair.

The following candidate was proposed for election as a member of the Society:—

Wilson, John Peter, 40, Addison-gardens North, Kensington, W.

The following candidates were balloted for and duly elected members of the Society :—

Gatliff, Charles, 19, Coleman street, E.C.
Heinrich, Johann, 36, Lower Kennington-lane, S.
Stokes, Charles, 65, Brook-street, Hanover-square, W.

The Paper read was—

ON THE TESTING OF CHAIN CABLES.

By Frederick Arthur Paget, Esq., C.E.

It is, no doubt, generally known that a select committee of the House of Commons is now considering a bill for the compulsory testing of the chain cables and anchors of merchant vessels. This may be said to lend a passing interest to a question which, however, needs no chance help in calling for our attention.

Without entering into lengthy statistics, or calculating the number of times that the total length of all the chain cables in actual use would measure round the world, we should be scarcely mistaken in the supposition that in different parts of the globe there are, at this very moment, many hundreds of valuable lives, and thousands' worth of property, in each case dependent upon a single link of the hundred fathoms that make up the length of an average chain cable; for there are situations in which a ship is often placed wherein the cable must be literally the thread of life of the vessel. To the seamen of the present age, the iron cable, though of comparatively recent introduction, is a common everyday thing. Those of the last generation could remember the time when only hempen cables were in use. The naval men of that time were thus led to look upon chain cables as the most precious gift ever made in modern times to the mariner—to repeat the words of the late distinguished Captain Basil Hall.

Now, although we have been testing chain cables according to certain Admiralty regulations established ever since 1831, although the naval administrations of France, Russia, and other countries have exactly copied these regulations, and although Lloyd's have adopted the Admiralty test—which is somewhat more than the so-called "merchant" test—it is a remarkable fact that a difference of opinion with regard to almost every point connected with the use and testing of chain cables still exists amongst engineers and other men of science. This differing of doctors is very strikingly shown by the Blue Book report from the 1860 Select Committee of the House of Commons on anchors and chain cables for the merchant service. One witness states that 50 per cent. of the loss of life by shipwrecks are due to bad cables and anchors; another that very few wrecks occur through bad anchors and cables. One objects to the Navy proof as being to high; another as too low. One witness considers that the cross-stay does not add to the strength of the link; another that the cross-stay is a great improvement. In the same way, directly contrary opinions were elicited from different witnesses with regard to the duration of cables under wear, their re-testing, re-annealing, and other points. A similar want of agreement on these matters exists in France; and it would thus appear that several interesting engineering questions, connected with the strength, the testing, and the re-testing of chain cables, offer a fair field for a practical examination.

According to the Admiralty regulations, an iron chain cable has to consist of eight lengths, each $12\frac{1}{2}$ fathoms long, including one swivel in the middle of every other length, and one joining shackle to each length. Neglecting the swivels and shackles, each link may be described as a cylinder, the axis of which is wound into a shape approximating to that of an ellipse. The width over all, or across the minor axis, is made $3\frac{1}{2}$ diameters (full) of the cylindrical bar. The length over all, or across the major axis of the supposed ellipse, is six diameters. The cast-iron stud across the minor axis is made 0·6 of a diameter in the centre, and one diameter at each of its ends. This stud not merely acts as a cross-stay, but also preserves the freedom of the joints, or what may be termed the mechanical flexibility of the cable. The weights are of course exactly fixed in the government tenders. The weight of, for instance, a one-inch link stay-pin must not exceed $3\frac{1}{2}$ ounces, and the weight, fixed by contract, of a hundred fathoms of cable, in 8 lengths, including 4 swivels and 8 joining shackles, must not be exceeded by more than 1-20th part. The experience of many centuries has determined the sizes of hempen cables for ships of a given tonnage; and, the sizes of the hempen cable being thus given, it is easy to substitute a chain cable of the required strength. Mr. J. R. Napier has proposed a formula, according to which one-eighth of the cube root of load displacement would give the diameter of the chain cable usually employed by steamers of the present form. In the Admiralty comparative table, showing the weights and strengths of stud chains and hempen cables, there is a noticeable relation between the girths of the hempen cables and the diameters of the iron employed in chain cables. The number of inches of the circumferences of the hempen cables pretty nearly expresses in lines, or twelfths of an inch, the diameters of the iron cables of equal breaking strength. The material of the links is No. 3 rolled bar, and very good cable bolts generally cost from £1 to £2 above common bars. According to experiments by Telford, Hodgkinson, Mr. Edwin Clark, and Mr. Kirkaldy, and also according to numerous experiments at Woolwich, we may safely take the ultimate breaking strength of cable bars at 24 tons to the square inch, and their limit of elasticity, under a tensile stress, at 12 tons to the square inch. These bars would stand a pressure up to deformation of 18 tons to the square inch, and 15 tons pressure at the elastic limit. The ultimate tensile strength of a round bar of this iron would thus be nearly 19 tons. According to the evidence of the leading man of the test house at Woolwich, in 1860, this ultimate statical breaking strength is only occasionally exceeded, when it rises up to about 20 tons for a one-inch round bar, or 25·33 tons per square inch. He also stated that a great number of experiments, made at Woolwich, showed the greatest breaking strength of one-inch chain cables to be only 28·31 tons. Contrary to the popular assumption that a stud link should be, in the direction of its length, twice the strength of a single bar, this result would show a loss in strength of 28·75 per cent. According to the comparative table published by the Admiralty, the one-inch bolts should stand 21 tons 8 cwts., and the stud link therefrom, 34 tons 5 cwts. It also appears to have been assumed (for it could scarcely have been proved by experiment) that the strength of the cable bolt, and of the link therefrom, both increase almost exactly in the ratio of the diameter of the bars. Thus, the breaking of two-inch bolts is given as 21 tons 8 cwts., $\times$ 4 = 85 tons 12 cwts., to which two tons are added; the strength of chain therefrom as 34t. 5 cwt. $\times$ 4 = 137 tons, and the proof as 18 $\times$ 4 = 72 tons. It is, however, well known to engineers that, as a rule, a two-inch bar is not practically four times as strong as a one-inch bar of even exactly the same make and by the same maker, and that the strength becomes less and less as the bulk still further increases. The proportions adopted by the Admiralty appear, however, to compensate for this loss, and there is very nearly the same average ratio of breaking strength to diameter in all chains from five-eighths to two inches. But, even according to the Admiralty tables, there is a remarkable amount of strength lost in forming the iron into the link. This loss of strength was well known to Sir Samuel Brown, the introducer of chain cables. He thus patented, in 1817, the straight link used in suspension bridges, and first applied it to the Brighton chain pier.

There are several reasons why a portion of the strength of the bar should be lost in forming it into a cable link. The principal causes are :—1st. The mechanical shape of the link; 2nd. The crushing stress undergone by the insides of the crowns; 3rd. The deterioration in strength of the iron through its being bent; 4th. The loss of strength at the welds.

In the first place, each link is, when the cable is pulled in the direction of its length, subjected to a transverse strain at each of its ends or crowns, and is somewhat in the condition of a curved beam loaded in the middle. An originally curved beam is, with regard to bending stress, in the same condition, at any cross-section at right angles to its neutral surface, as a straight beam under the same moment of flexure. The moment of flexure of one end of a common unstayed link can be expressed in inch-pounds by multiplying half the span, or half the distance in the clear, by the load in pounds. In the case of the stayed link, however, the moment of thrust of the cross-stay has to be subtracted from the moment of the bending force. The mechanically weakest part of any link is thus at the crowns.* Now, it is a curious fact, that all the writers on the strength of materials, from Professor Peter Barlow, Mr. Edwin Clark, and others, down to General Morin, in 1862, give the strength of a link furnished with a cross-stay to be equal to that of the iron of which the link is made.

In a mathematical sense, the contact between the links is only at a point, because it is a case of two cylinders touching each other at right angles. Under a load, this point will spread out to a surface of an area given by the amount of the load and by the compressibility of the iron. This surface will then probably increase, in the case of a one-inch cable under a load of nine tons, up to more than half a square inch. And thus at the ends, the softer and more ductile the iron, the sooner will it be worn away in practice, and the progressive deterioration caused by this crushing action will also be furthered by the friction.

An attempt to account for the reduction in strength through the bending of the cylindrical bar has next to be made. Wrought iron is known to be a crystallized body, belonging to the cubic system. Now Mr. Mallet, in his important work "On the Physical Conditions involved in the construction of Artillery," has shown that these crystals are not grouped amorphously (or without distinct arrangement); but that they always take a certain determinate position. He has developed the law that "iron, whether in the state of cast or of wrought iron, has the principal axes of its integrant crystals arranged in the lines of least pressure within the mass" while exposed to pressure and heat in progress of manufacture. The principal axes of the crystals in a rolled bar would thus be set in a direction coincident with the length of the bar, and, from the property of malleability possessed by these metallic crystals, they would further take, under the pressure of the rolls, or the impact of the forging hammer, the longitudinal extension known as the "fibre" of wrought iron. Mr. Edwin Clark found that bars cut longitudinally and transversely to the fibre of the same plate of an excellent quality of iron, gave with the fibre a strength of from 19·66 to 20·2, and across the fibre a strength of only 16·7 tons to 16·93 tons. The ultimate elongation also of the plate in the line of the fibre was double as great as transverse to it. A great number of experiments by Mr. Kirkaldy gave somewhat similar results. He found that the difference averaged from 21·7 to 2·1 per cent., the mean difference in the whole being 9·8 per cent. in favour of the direction of the fibre. The respective ultimate elongations were also in almost the same rates as those found by Mr. Clark. It would thus appear from these experiments, and from a consideration of Mr. Mallet's law, that both the elastic range and breaking strength of wrought iron of any given quality are, to a certain amount, dependent on the direction of the crystalline axes in relation to the strain; and further, the elasticity would be at a maximum in the direction of the principal axes of the crystals, or "line of fibre." The crystals in a bar subjected in the direction of its longitudinal axis to a tensile or a compressive stress, would thus be in the most favourable condition with regard to its ultimate breaking strength and its elastic limit. But when, say, a red-hot bar is being bent, the principal axes of its crystals would, according to the law of cross-bending strains, arrange themselves above and below a neutral axis in the direction of least pressure within the mass; the neutral axis would probably pass through the centre of gravity of the bar, the fibres on the concave side would be compressed, and those on the curved side would elongate in the ratio of their distances from the neutral axis. The hot iron itself would be, at any rate on the concave side, under a somewhat similar influence as when passing through the last pair of rolls, but the directions of least pressure, instead of being coincident with the length of the bar, would be at right angles to tangents to the neutral axis. Much of this is, of course, founded on several unproved assumptions, but it is at any rate evident that the molecular arrangement of the iron at the crown of the link is in the worst condition for resisting the tensile and compressive strains on each side of a neutral axis that make up the compound action of a transverse stress. The late Professor Daniell's process for unmasking the fracture and the arrangement of the fibre of wrought iron, by immersing the piece in dilute hydrochloric acid, would doubtless reveal a distortion of the crystals round a neutral axis.

It would thus appear that the crown of the link is its weakest part. This is, however, very far from being practically the case. Each link has of course to be welded up, and the weld is in one of the sides, with a long scarf, in order to get a large welding surface. When we recollect that there are, in round numbers, 1,800 links, and, consequently, 1,800 welds, in a one-inch hundred-fathom chain cable, and also that the efficiency of the cable depends on each individual link, the paramount importance of the welds is obvious. In nine cases out of ten, while in use and while being tested, the links are found to give way at the sides. Breakages would, *cæteris paribus*, have a tendency to occur at the welds with good iron but bad

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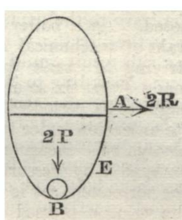
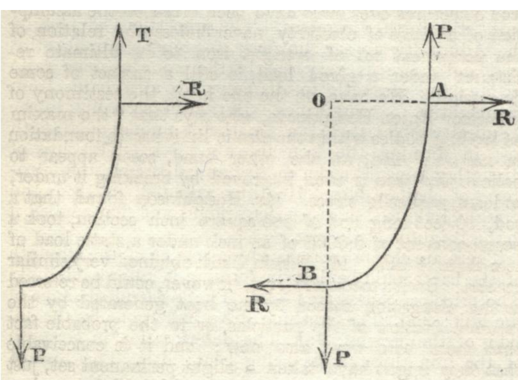
* For the sake of simplicity, let us suppose the cross-sectional area of the link as infinitely small compared with its major and minor axes, and suppose it provided with a cross-stay. Let 2P denote the whole pulling force; 2R the thrust of the stay; T the tension at A. For the equilibrium of the quarter link, B E A, we have the forces P, R, T, and the forces at B arising from the left-hand quarter at A. From symmetry this must be horizontal (in the figure), and we must therefore have:—Force at B = R, and T = P. The moment of the bending force at B is therefore not P × oA, but only P × oA − R × oB. On the other hand, when the link is on the point of breaking by opening at B, the tension will not be equal to the ultimate tension throughout the section at B, but only at the lowest point, and when this has given way a little, the tension, previously supported, is thrown on a fibre higher up, which then gives way, and so on. Hence the strength is less than if the tension were throughout the section as great as possible.





workmanship, and in the iron, and not in the weld, if good workmanship but bad iron were employed. The uncertainty of welds is in any case well known to practical men. Mr. Kirkaldy has made some eighteen experiments on the relative strengths of welded joints in wrought iron. Some of these welds were made by a chain-maker. Only six of the specimens broke solid away from the weld, and in every case there was a loss of ultimate breaking strength averaging from 2·6 to 43 per cent., the mean being nearly 20 per cent. As with almost everything else belonging to the subject of chain cables, one of the witnesses before the Committee of 1860 raised the question whether the position at one of the sides was the best for the weld. Mr. Smale, of Woolwich, proposed to weld the link at the crown, as there would thus be more room for the smith, and any bad weld would be less hidden by the cross-stay. The crown is, however, as we have seen, *ab initio*, the weakest part of the link. Besides, if a weld at the side gave way, the other half might catch and save the cable; at the same time, however, a sudden giving way at the weld would cause an instantaneous distortion and probable rupture of the opposite side, as the sudden "run" of the cable would act with an impulsive force. In fact, when iron cables were first introduced, the welds were made at the crown, but the plan had to be given up. It is clear enough that there are, *cœteris paribus*, three weak places in a link where any effects of stress would first show themselves,—the two crowns and the weld at the side.

We thus see what a powerful element of uncertainty is brought by the uncertainties of workmanship into such an apparently simple thing as a chain cable. When, however, we remember that the very best wrought-iron of commerce is, to use the words of the well-known metallurgist Saint-Claire Deville, but a metallic sponge, like platinum, the pores of which have been simply closed up by pressure or percussion; that, in one word, ordinary wrought-iron has never, as wrought-iron, been fused, it will be seen that the uncertainties qualifying the material itself are still greater. Mr. Mallet thus found that while the original hammered slab of a very large forged mass had a breaking strength of 24 tons to the square inch, it fell progressively to 17 and 16 tons at the different places of the mass, down to even as low as 6½ tons in some parts. Unless this iron had been burnt, its tenacity could doubtless have been restored, and if drawn into wire, its breaking weight might have been increased to perhaps ninety tons to the square inch—at least before annealing. An average of 188 experiments, made by Mr. Kirkaldy on rolled bars, gave a maximum breaking strength of 30¾ tons, and a minimum of nearly 20 tons to the square inch. These influences of the manufacture merely on the quality of wrought iron are almost independent of the chemical constitution of any individual bar. For instance, until it be proved to the contrary, there are many reasons for the general belief that the cold shortness of wrought iron is due to the presence of silicon and carbon; and its hot shortness to that of sulphur. A fractional percentage of copper also makes wrought iron hot-short. In truth, there are probably no two bars or parts of a bar of an exactly similar chemical composition, or in an exactly similar state of molecular aggregation, and therefore of an exactly similar breaking strength or elastic limit. Even these are only a few of the elements of uncertainty in structural materials. But when we further take into account the varied strains of extension, compression, distortion, twisting, and bending, to which mechanical structures are more or less subject; that the work done by a gradually applied load is doubled if this load be applied suddenly; that the impulsive strain of a moving load is generally more or less intensified by vibration; and that the varied shapes and arrangements intended to receive these strains must be often as much fixed by financial as by scientific considerations, then the reason that the best engineering practice makes the ultimate strength of a wrought-iron structure from four to six times the working load must be even popularly evident. But these factors of safety are not sufficient. The structure must be tested as searchingly, and as far as is consistent with safety—as far as is possible without injuring the material and its relation to the structure. In our case this limit is, in the main, given by the limit of elasticity of wrought-iron under extension, as this limit is less for wrought-iron than that of compression. It is also self-evident that the mode of testing adopted ought to approximate as nearly as practicable with the kind of stress the object is intended to undergo in practice. It is also evident that if circumstances allow us to exceed this limit, if, in fact, we can push the test as far as the breaking strength of a portion, or of an individual piece of the object, we shall obtain the safest amount of information about its qualities. In this way guns and plates are both tested to destruction. In order to test the probable performance of rails under a moving load, a certain number, taken from a lot, are broken by a falling weight, the distance between the supports and the height of fall being fixed by contract. The French test their railway carriage axles in a somewhat similar manner. There is no test so good as a blow for detecting a false weld. In Sweden they do not confine themselves to the usual gunpowder proof for gun barrels, but two or three sharp taps with a hammer are given along the breech, which have an immediate effect on a bad weld. All the whipple chains for the carriages of the Royal Swedish Artillery are tested by letting the loose end fall from a height double the length of the chain, after being attached to a weight. The anchors for the French imperial marine are tested by being dropped from a determined height for each size. The axles for the carriages of the Messageries Générales and the Imperial Artillery are tested by the impact of a falling weight. All the swords and sabres for the army are tested by striking the blades on a block of wood. When we advance from details to considerable structures, we are, of course, obliged to very carefully confine ourselves within the limits of elasticity. After loading a railway bridge with the greatest passive, or perhaps impulsive load that would ever come upon it in practice, the deflection, and the permanent set, if any, are both carefully noted. As a boiler is subjected in practice to a complex train of mechanical and chemical forces that are always striving to break their bonds, its ultimate strength is made from six to eight times the working stress, and it ought to be periodically tested to half its working pressure. Its extension under this pressure is sometimes—and should always be,—measured by the volume of water that is pumped in by pressure after the boiler has been filled; while the permanent set is determined by the difference between the volume pressed out by the contraction of the boiler when the pressure is withdrawn, and the volume of the water that remains in the boiler after the test—allowance being of course made for any slight leakages and sweating at the joints. In first-class locomotive works the deflexion and permanent set of the steel springs are always tested in an apparatus for the purpose. It may here be remarked that, although the designs of all the successful wrought iron structures ever built have been based on the assumption of a limit of elasticity, nevertheless the relation of the permanent set of wrought iron to its ultimate resistance under a given load, is still a subject of some discussion. We have, on the one hand, the testimony of Professor Eaton Hodgkinson, who says that "the maxim of loading bodies within the elastic limit has no foundation in nature;" and, on the other hand, some appear to believe that iron is even improved by breaking it under, at least, a tensile stress. Mr. Hodgkinson found that a rod, 10 feet long and of one square inch section, took a permanent set of 0·0005 of an inch under a static load of less than 1¾ tons. Mr. Edwin Clark obtained very similar results. Such a microscopic set, however, could be referred to the elongation caused by the heat generated by the internal friction of the particles, or to the probable fact that these bars were also new; and it is conceivable that they might have taken a slight permanent set, just as new ropes take a permanent set, without injury, when

the strain is first applied. There are, indeed, very few forms of wrought iron in which its internal particles are not, *ab initio*, subject to some mutual strain. At any rate, these elongations were very slight, and increased uniformly up to tensions varying from about 10 to 15 or 16 tons on the square inch. Beyond these strains the bars elongated in an irregular manner, until they at last broke. At the same time, as Dr. Rankine remarks, the demonstration by Mr. E. Hodgkinson that a set is produced by a strain much less than what would injure the specimen, renders the determination of the proof-strength a matter of some obscurity; but Dr. Rankine points out that the best test now known is the not producing an increasing set by the repeated application of a load. Some years ago, Mr. Loyd, of Woolwich, made certain experiments which have been cited as proving that a breaking strain does not injure iron, even when this strain is four times repeated; or rather, that after breaking a bar into, say, two pieces, the two pieces are thereby made stronger. In, for instance, experiment 2, the 1⅝ bar marked C was found to break with 33¾ tons, with a stretch of 9¼ inches in 54 inches; a piece of this bar then broke at 35¼ tons, with a stretch of only a quarter of an inch in 36 inches; another piece of the bar, 24 inches long, was broken at 37 tons, with a stretch of one inch; and at the fourth and last breakage was found to give way at 38¾ tons, but without any stretch at all. Results of a similarly delusive kind, obtained by Professor Walter Johnson, were communicated by him to the United States government in 1845. He found that by heating a bar to a temperature of 400° Fahrenheit (or the temperature of steam at about 250 lbs. pressure), and stretching it permanently for about 6½ per cent. of its length, it, on being broken, gave an ultimate breaking strength about 20 per cent. higher than a portion of the bar that had not been heated and stretched. He therefore supposed that, to use his own words, "the value for useful purposes, added to a bar of iron by thermo-tension, when the increase of both length and tenacity is taken into account, may be safely set down at 26 per cent. of its original value. It sometimes exceeds 30 per cent. On a single cable, 100 fathoms long, made of iron 2¼ inches in diameter, weighing about 15 tons, and attached to a line-of-battle ship, the gain, in true commercial value, would not probably fall short of 600 dollars." A machine was made by the American government, in order that the Professor might apply his principle of "thermo-tension" directly to chain cables, but as nothing else ever appears to have been heard about the matter, we have thus, as usual, lost another of the lessons always taught by scientific accounts of scientific failures. The pitch chains of the old engines of the *Great Britain* are stated, by Mr. Guppy, to have been stretched one-eighth of an inch while at a low red heat. This was, no doubt, an excellent method for testing the soundness of the work. Captain Blakely also stretches the hoops that are shrunk on his guns. This is done on a maundrel, and while the rings are at a red heat; but it is stated that only one-sixth of the breaking strain of the cold metal is applied. The action of the maundrel also probably rearranges the crystalline aggregation which had been disturbed by bending the ring from a straight slab. The red heat of iron is only visible in daylight at a temperature of 1,077 degrees Fahr., and the heat used by Professor Johnson was only from 400 to 500 degrees. But the "gain of length"—the permanent set, in fact—of from 5 to nearly 7 per cent., sufficiently shows that the bars had either been broken or were close upon fracture. His results, in fact, merely anticipated those of Mr. Loyd. The breaking strength of his bars was doubtless increased, but with a proportionate diminution, perhaps, indeed, a complete destruction, of their elasticity. They were rendered harder, for what is the hardness of a body but the resistance of its particles to any temporary readjustment? The longitudinal elongation was accompanied by a lateral contraction of the cross-sectional area that would reach its culminating point at the part where fracture happened to take place. Exactly the same argument, founded on similar experiments on cables themselves, was used before the 1860 Committee, in order to prove that cables are not injured by a breaking strain; but a mere statement of the progressive diminution of the elongations would have detected the fallacy.

The apparent increase of ultimate strength through successive breakages, thermo-tension, and much of the high static breaking strength acquired through cold rolling, and cold hammering, even through wire-drawing previous to annealing, are referable to an increase of hardness, to an increase of the difficulty of the gliding to and fro, to a resistance to the inter-mobility of the particles, to, in one word, a diminution of elasticity. If the numerous experiments that have now been made on iron do prove anything, it is that the breaking strength does not indicate the quality—the breaking strength must be taken conjointly with the elongation. The true measure of the mechanical value of wrought iron is simply the sum of the products of the successive loads and the increments of elongation—in other words, the resilience of the bar or the deflection of the beam, or the work performed in producing the stretch or deflection. We thus see the value of Poncelet's symbols T_e and T_r, advocated with such ability in England by Mr. Mallet. Upon the just balance of strength of fibre, or high breaking strength, and extensibility or ductility, depends the mechanical or structural value of iron.

The Navy test for chain cables is stated to be the result of a number of careful experiments by the late Sir Samuel Brown, and it was adopted by the Admiralty in 1831, when chain cables were fairly established in the royal service. The test adopted by the French Navy is almost exactly the same, and in Russia and the States it is exactly the same, as both those countries use our own measures and weights. Every chain cable is proved by a gradually applied stress of 630 lbs. for each circular one-eighth of an inch of the area of the bolt of which the cable is made, or 11·46 tons to the square inch on each side of the link.

Assuming that a link is subjected in practice to a tensile stress, and as the proof strength is generally fixed at double the working stress, this would correspond to nearly 5¾ tons on the square inch. There is thus a very close correspondence between the working stress assumed for chain cables and the Board of Trade limit of 5 tons to the square inch, imposed about 16 years ago, for both the tension and compression of the wrought-iron of railway structures. The chain cable of a ship is also evidently subjected to impulsive forces. It is true that a ship, when struck by a sea, in most cases merely lifts the weight of her chain, the catenary curve of which thus acts as a kind of water-brake; but a very heavy sea must occasionally bring a sudden pull on the cable, and in shoal water the sudden strain must be almost solely taken up by the resilience of the cable, or rather by the deflection of the series of beams composing the cables. Much security is, however, afforded by the fact that a cable is generally only strained during a brief interval of time. But few cables can stand a sudden nip at the hawse-pipe; and we thus see that lateral as well as longitudinal strength is occasionally required in a cable.

If two one-inch diameter cable bars of average quality, and, say, each ten feet long, be put into the hydraulic press generally used for testing cables, the following appearances will probably be observed:—If new, they will take a very slight set under a stress of about 1¼ ton to the square inch, but if this stress be gradually increased, and alternately eased off and put on several times, the set will not increase until the true elastic limit or proof strength of the material be exceeded. In our case this limit will probably be 12 tons to the square inch, which is thus higher by a little more than half-a-ton than the 11·46 tons navy test. At the Admiralty proof stress, each of the bars will have a probably total elongation of more than one-twentieth of an inch, and a permanent set of six-thousandths. Beyond this strain the set will very rapidly increase up to, perhaps,

two inches, when the bars will break under a load of 24 tons to the square inch. But the phenomenon the most important in its consequences, consists in the contraction of cross sectional area undergone by the bar through the stretch. According to a theoretical investigation by Poisson, the relation of the contractions to the longitudinal elongation should be $\frac{1}{4}$; and Wertheim's experiments led him to believe that this relation should be $\frac{1}{3}$. Cauchy, Stokes, Maxwell, Rankine, and Lamé, have also mathematically investigated this question, and have arrived at results differing from those of Poisson, which were founded on a special atomic hypothesis. But the permanent sets that show themselves in ductile bodies, like annealed iron, under very slight loads, and the so-called internal frictions observed by Dr. William Thomson in metals under tension, would cause this relation of contraction to elongation to differ for every different state of a metal. To Kirchhoff is due a remarkably important investigation carried out in 1859, into the relation of the contraction to elongation under tension of hard steel wires—which may be said to approach the nearest to the ideal of a body possessing equal elasticity in different directions. His experiments, conducted with great delicacy, gave a relation of cross sectional contraction to elongation of 0·294. As we have seen, according to the Admiralty tables, a one-inch cable bolt ought to have an ultimate breaking strength of not less than 21 tons 8 cwts. to the circular inch, or more than 27 tons to the square inch, and the link ought only to break at 34 tons. It is, however, very seldom that these strengths are obtained in practice. The ultimate elongations of the bars or the cables are not stated in the Admiralty tables. General Morin relates that the fine charcoal iron, made at Guerigny by the French government, expressly for chain cables, sometimes elongates even more than one-fifth of its original length before breaking, and this amount is probably the utmost that it is possible to give to wrought iron bars.

When the cable itself is placed under the dead pull of the press, it is tested in three different ways. It is first strained up to 11·46 tons in the square inch sectional area across the double section of the link. While for about three or four minutes under this stress, the cable is subjected at different parts of its length to blows from a round-faced hammer. Different sized hammers are adopted in proportion to the size of the chain, and each fathom generally receives one blow. Each link is then carefully examined. Two or three links are broken up to detect, by its bluish tinge, if the iron has been at all burnt in the working, and also to make some estimate of the quality of the iron from the surface of the fracture, and the other appearances known to engineers. Some difference of opinion also exists, both in France and in England, as to the amount of security afforded by these tests, and whether the test of 11·46 tons on the square inch, and more especially the blows of the sledge, do or do not injure the cable. In 1855 it was attempted to introduce a compulsory government test in France for the chain cables of merchant vessels. A letter was addressed by M. David, an influential chain cable manufacturer at Hâvre, to the then imperial minister of public works, advocating a compulsory test, from motives of humanity to the ships' crews, and of public economy. A system of periodical re-testing, for every ten or twelve years that the cable had been at work, was also proposed. The attention of the then minister of the French marine was directed to the statements put forth, and Admiral Hamelin ordered an official investigation of the question. The results shown forth in the report would appear to have proved—at any rate to the satisfaction of the Imperial administration, that —1st. "The proof test of 17 kilogrammes, or even of 20 to 21 kilogrammes per square millimetre of section of the link, is not enough either to prove the good workmanship of the cables or the quality of the iron employed; 2nd. That a higher proof than 20 to 21 kilogrammes cannot be applied several times to cables without affecting their quality; 3rd. That the differences of useful effect between different presses often lead to error with respect to the absolute value of the tension employed. . . . . The sum total of these results therefore shows, continues the minister, that, on the one hand, an increase of the proof test would not be of much effect in detecting bad material and workmanship, and on the other, that it would be dangerous to increase the test. The required security can only be obtained in a well-understood system of manufacture; and therefore, besides the test in the press, it is necessary to scrupulously choose the special quality of iron required; to accurately examine each individual link after the testing; to break up any questionable link; and to choose the most skilful and trustworthy operatives." In one word, the minister of the marine did not consider a government inspection of chain cables intended for the French merchant service as a practicable thing. It is to be remembered that all the chain cables for the Imperial navy are manufactured by the government.

Now there can be no doubt that the proof of 11·46 tons to the square inch is not enough of itself to test the quality of the workmanship, or, more definitely, the perfection of the welds. For this reason Mr. R. Bowman advocated before the 1860 Committee an increase of the test. It is clear that, as the sides are only tested up to little more than 11·46 tons, and as they would break at only, say, 24 tons to the square inch, less than one-half the sectional area of the iron would stand the test if applied only tensionally. As, however, through the cross-bending strain at the two ends, the link slightly tends to assume the shape of a lozenge, the weld is more severely tested than would at first appear. There is a certain difficulty in detecting a bad weld, upon the nature of which some practical light has been thrown by some experiments of Mr. Kirkaldy's on bars grooved round their circumferences. The matter had been previously investigated by the writers on elasticity, but Mr. Kirkaldy was the first to practically test the question. Bars grooved at any particular part down to a given diameter, gave a much higher ultimate breaking strength than bars of a diameter all through equal to that at the reduced part of the grooved bar. The wider parts on each side resisted the tendency to draw out, and a great apparent strength was thus obtained. The extent of this apparent gain was as much as 37½ per cent. in some of the pieces, while the average gave 18·63 per cent. in favour of the grooved specimen. Here again we see the falsity of taking merely the breaking strength into account, for although the breaking strengths were thus increased, the elongation, and the contraction of area attendant on elongation, were proportionately less. It will thus be seen that a bad weld may be impaired by a strain in excess of the elastic limit due to the quality of the iron and the cross sectional area of the solid metal, and that, although it is thus injured, it may not show signs of the injury. On the other hand, some security is given that a bad weld may be detected, from the fact that rolled iron is well known to be somewhat hardened by being hammered, and the welded-up side of the link would thus be less extensible than the opposite parallel side, and would thereby be rather more strained. It is evident, however, that though the test can scarcely be too high for the welds alone, the proof of more than fourteen tons to the square inch, proposed by M. David, would clearly be too high for the cable. M. David, indeed, stated that he tested his cables up to this amount, but it appears that the pressure he used was not accurately measured. Indeed, there is no doubt that very few cables would stand the ordinary proof if repeated sufficiently often, or if it were put on and eased off a succession of times, upon the plan shown by Dr. Rankine. As it is, the permanent set taken by cables is, on an average, from 4 to 6 feet in 90. But the best proof that this single application of the test for a short time does not injure good chain cables, is seen in the fact that it has been adopted all over the world for more than thirty years. We are, however, in a dilemma. To increase the proof would evidently be to in-

jure the link, while the detection of a bad weld has, in any case, to encounter the difficulties just mentioned. These questions can only be met by a most careful inspection of each individual link. The quality of the iron can also be very closely tested by breaking up two or three links. The most searching tests, however, are the hammer blows given while the chain is under tension. Adapting a well-known and excellent illustration, this will be at once evident when we remember that a $1\frac{3}{4}$-inch chain cable, made of glass, would give the same ultimate gradually-applied breaking strength as a one-inch iron cable—but it would not be likely to stand the hammer test. On the other hand, a cable of india-rubber, although not to be broken by the hammer, would at last be torn in two by the press. In fact, the hammer test approaches nearer than any other to the kind of work that will have to be done by the cable when at sea. Besides, the mere form of a chain renders it, *per se*, liable to continual shocks and jerks, and this must be encountered by a special quality of material, and that this material has really been used must be shown in the proving house.

Mr. Pope, the surveyor for Lloyd's at Liverpool, gave it as his opinion, before the Committee of 1860, that the navy test was too high, and had a tendency to injure the chain. This might be true for a chain of a bad material, but not for a chain made of iron with the high elastic limit that should alone be used for chain cables. He proposed to test a short piece to destruction, and then to test the entire chain up to half the Admiralty proof. Apart from the expense and destruction of material by this proceeding, there can be little doubt that half the usual test would not detect all the bad welds, and the distinctive peculiarity of a cable consists in the fact that a single bad weld is sufficient to cause the entire loss of the chain.

As we have seen that a cable consists substantially of a series of small curved beams, it would be only a natural inquiry to ask why the sum total of their deflections, represented by the temporary elongation of the cable, and why the total permanent set should not be both registered, and be both taken into account when estimating the quality of a cable. There are, however, several influences that would greatly disturb an accurate deduction. It might, at first sight, be supposed that the defective welds would elongate in the inverse ratio of their areas of solid metal to that of the links. This, as we have seen, is not the case, and even if it were the case, the action would affect the deductions therefrom by variable and uncertain quantities. The links will also bed against each other to an amount given by the hardness of the iron. There can be no doubt that the extension must be taken into account with the breaking weight, when the quality of a bar has to be estimated. But even with bars this varies considerably, not merely in different qualities, but also, as was shown by Mr. Kirkaldy, in specimens of the very same brand. These results were also obtained under tensional stresses alone, and when we come to the combination of transverse, tensile, and directly compressive stresses to be found acting on a link, the varied ways in which these stresses act on varying qualities of iron would scarcely render the deductions from the elongations and set sufficiently trustworthy. Again, to take an extreme case, if one half of, say, 50 fathoms of cable were made of a very bad kind of iron, and the other half of a very good quality, it would be difficult to draw any right deduction from these appearances. As it is, however, the permanent set is generally registered.

There is probably no metal the strength of which is influenced in such a remarkable way by temperature as iron. As M. Baudrimont showed in 1850, the tenacity of iron is less at 100° C. than at 0° C., but at 200° it is greater than at 0°, and these results have been exactly confirmed by Dr. Fairbairn in some experiments on boiler plates, communicated in a paper to the British Association. At yet higher temperatures this tenacity is of course diminished; and Seguin has shown that iron, the tensile strength of which could be represented by 100 at 10° C., had this tenacity lowered to 90·5 at 370° C., and to 58·7 at 500° C. In the royal dockyards of Woolwich and Portsmouth the atmospheric temperature during the testing of each anchor or chain is carefully noted, although the proving houses themselves are kept at a mean temperature of 56° Fahr. by means of stoves, which also thus save the water pipes from freezing. This temperature of course falls a little during the winter and rises in summer, as the heat in the shade generally varies in England from about 76° to perhaps 34° Fahr. The action of frost on iron has not been completely investigated; and Dr. Percy recommends that some accurate experiments on the question be undertaken by the Institution of Civil Engineers. The daily observation of practical men has, however, as in so many other cases, preceded the deeper investigations of science. All workmen know that their tools, such as picks and chipping hammers, which have to undergo percussion in frosty weather, are then more liable to get broken. All chains are well known to be more subject to snap under the same circumstances. There is always a notorious increase of accidents through breakages, both in the permanent way and rolling stock, of railways during frosty weather. It is stated that during the severe winter of 1860–61, 498 rails were broken on the Chemin de Fer de l'Est, from the 11th December to the 31st January inclusive. No less than 258 were broken from the 21st to the 25th of January, during which period the thermometer descended to—7·8°, and even to —16° centigrade. General Morin relates that during the northern campaigns of the first empire the artillery veterans used to believe that wrought-iron was subject to freezing, and after the long winter bivouacs they never began their day's march without striking the gun-carriage axles in the direction of their length, and the vibration thus produced was said to "thaw" the iron. An intense cold is also said to have enabled the French garrison of Hamburg to disable the cast-iron siege guns, by knocking off the trunnions before evacuating the place. Mr. Lenox stated, in evidence before the 1860 Committee, his belief that a cable would stand a test in warm weather that it might not in cold. The crews of the fishing vessels on the coast of Nova Scotia find that the cold renders their cables so brittle that a length of hempen cable is used for the portion out of the water, while the anchor end is kept from the vicissitudes of the atmosphere by the usual average temperature of the sea. A few experiments made by Mr. Kirkaldy showed that the breaking strength of a bar is slightly reduced by freezing when a gradual breaking load was applied, but that this difference between a frozen and an unfrozen bolt is much more increased by a suddenly applied load, being 3 per cent. less when frozen. The usual way adopted by French engineers to test rails is, as we have seen, to prove a percentage of the lot by means of a falling weight. Some tests were carried out a few years ago by M. Couche, on a number of rails, of very good quality, from the Anzin works. The monkey weighed 300 kilogrammes, and the distance between the supports was 1m. 10. When the thermometer varied from — 4° C. down to — 6° C. the weight had only to be raised, in an average of twelve experiments, to a height of 5ft 6in. in order to break the rail; but when the thermometer rose from + 3° to + 8° C., then the weight had to be lifted for a fall of 7ft 9in. Similar experiments, conducted in 1860, showed that a difference of temperature from — 4° to + 5° Centigrade was sufficient to greatly influence the height of fall necessary to break the rail. It is not unnatural to suppose that the particles of iron, after being worked at a heat and allowed to cool and set at a medium temperature, should, when that temperature is lowered, get into a state of mutual strain; or that any initial mutual strain should be thus intensified. The toys made of suddenly cooled glass, known as Prince Rupert's drops, are exaggerated instances of a similar action. The outside portions of a bar of whatever size, would evidently cool and consequently contract first of all. The inside portions would also at last cool, but, having kept the out-

side portions distended, when the inside does cool, it then becomes a question, to be determined by various circumstances, whether it would pull the outside shell into a state of compression, or whether the outside shell would draw the inside into fissures by tension. A somewhat similar explanation is given by Mr. Mallet of the rents caused in the interior of very massive forgings, and this state is probably always induced by the conditions of cooling in a small bar, but with, of course, a smaller range both as to size and temperature. In any case, it is apparent that a ductile, elastic material ought to be less affected by these doubtlessly complicated conditions of tensile and compressive strains. It is, therefore, probable that a hard, harsh, iron would be more affected by frost than a soft ductile iron, and also that the breaking strength of both qualities would be less affected by cold than their extensibility. It is even by no means improbable, though the fact would be difficult, or at any rate very expensive, to prove, that the breaking weight, or the elastic limit, or both, of iron, is or are different for every degree of heat. A bar is perhaps cooled down in the rolling shed the medium atmospheric temperature of, say, 52° Fahr. At a lower temperature, at a temperature, for instance, of 32° F., its static breaking weight is increased, but its power of elongation under stress is probably diminished. At, say, boiling point, its breaking strength is diminished, but its power of elongation is increased. These remarks to some extent meet the results of Baudriment and Fairbairn. Unfortunately, Baudriment has not recorded the elongations, and his experiments were made on wires only one millimetre in diameter when at a temperature of 16° C. Dr. Fairbairn did find that the elongations of plates increased very closely with the temperature, but his experiments are not sufficient in number to be taken as conclusive; and, as Dr. Percy remarks, many more experiments are required on the action of frost on iron. If it could be shown, for instance, that the crystals of iron expand to different degrees in their different axes, this would probably, *per se*, meet the scarcely-to-be doubted fact that iron is rendered brittle by frost. As the chain cables of a ship are alternately exposed to the utmost extremes of atmospheric temperature, this question is here of peculiar importance.

The question as to the re-testing of cables that have been in use for a certain time is yet unsettled, but the inquiry is of scarcely less importance than that of the first testing. There are many applications of wrought iron in which it is subjected to impulsive stresses, often more or less accompanied by vibrations, and in which, nevertheless, the detail or structure has to conform to certain narrow limits of size and weight. Such is the case with most applications of chains; for instance, to cranes, inclines, forge-slings, &c. Such is the case also, more or less, with railway axles; the axles of carriages on rough common roads; the gags of helve hammers; the porter bars fixed to the blooms whilst under the hammer; the iron wires of some piano-fortes; and many similar applications of wrought iron. The simple fact that only one-half of the gradually applied stress required to produce the proof strain will, if applied suddenly, of itself produce the proof strain (which if exceeded would injure the piece), goes a long way in explaining the matter. Where great interests of life and property are involved in the safe action of these applications of iron, the irresistible logic of facts has sometimes caused preparatory allowances to be made for these "fatigues of the metal." The axles of the London omnibuses are stated to be always renewed after having run a certain fixed mileage. This system is also carried out with the carriages of the Messageries Générales, the axles of which are changed after having run a limit of 40,000 kilomètres. The Honourable the Corporation of the Trinity House entirely renews all the moorings of the light-ships every four years —one-fourth of the number yearly. This limit of time gives the measure of the perfect efficiency of a good cable, well proportioned to its work, and in constant use day and night. Cables in ordinary ships are of course much less, or rather much more slowly, subject to deterioration. We have seen that M. David fixed the time after which a cable in ordinary use should be tested at ten or twelve years. Mr. Macdonald, of the Liverpool testing house, stated, before the 1860 Committee, that he would examine a cable after any long voyage—such as to India or Australia. The late Mr. Green, the great shipowner, explained that this was done with the mooring tackle of all his ships. An experienced pilot, Mr. G. J. Thompson, said that it should be made imperative to re-test chain cables every six years, and Mr. Smale fixed this limit at seven years. Mr. J. R. Clarke, however, the chief clerk of the store office, stated that there were many sound cables in store twenty years old. It is clear that it would be very difficult to fix a limit of time that could be applied to all classes of ships. The cables in the royal ships are scarcely so often or so severely tried by use as those of some merchant vessels. A cable might remain good for many years, and yet at last be injured in a single storm. Apart from accidents, such as abrasion on rocks, or against a sharp-cornered anchor stock, or similar causes, there are three main conditions affecting the duration of cables and furthering their progressive deterioration under wear:—1st, the friction and abrasion at the crowns; 2nd, rust and corrosion by the sea water; 3rd, undue strains on the cable, and in excess of the compressive and tensile elastic limits of the materials. The average amount of abrasion and consequent wear at the crowns could only be determined by a statistical comparison of the deterioration of a number of cables, worked under similar circumstances, through a certain period of time. No full observation of this kind seems to have been yet made. The same appears to be the case with the deterioration of iron cables by rust and corrosion. Mr. Mallet has observed, "that the metallic destruction by corrosion of iron in sea-water is a maximum in clear sea-water of the temperature of 115° Fahr., that it is nearly as great in foul sea-water, and is a minimum in clear fresh river-water." It also appears that, the finer and more equable the quality of the iron, the slower is its corrosion. The alternative action of the air and the sea-water in ordinary cables must have some influence on their deterioration. Again, at a depth of, say, 100 fathoms, there would be a pressure of nearly 17 tons on the square foot, and this pressure would search out any slight crevice, or any slightly defective weld that had escaped the test. It is at these places that the corrosive action of the water is most felt. It is a well ascertained fact that the spongy mass of mechanically compressed crystals we call wrought iron, is porous, as water can be forced through it at comparatively moderate pressures. It is also well known that the hydrated oxide of iron we term rust performs the part of an electro-negative element when in contact with metallic iron, which is then electro-positive. When iron is rusting in the air, the moisture of the atmosphere is the exciting liquid, but this voltaic action must be greatly intensified in the presence of sea-water. I have noticed the interesting fact —which deserves more investigation than I have yet been able to give to it—that in the links of a great number of chains the wrought-iron is much more eaten away at the sides, where it is in contact with the cast-iron cross-stay. The same action was stated, in a number of the *Times* of last year, to have been observed on the wrought-iron tie-rods in contact with the plates of a cast-iron sea-water tank which burst last June at Woolwich. I had lately occasion to examine a number of old chains, after they had been cleaned, and after the rust had been knocked off with a hammer. All the cast-iron cross-stays, almost without an exception, were slack. Each link was thus temporarily reduced to the condition of an unstayed link, the ultimate strength of which, compared with a stayed link, is generally taken to be in the ratio of 7 to 9. When the cable is in use, the progress of this undoubtedly voltaic action in weakening them will be aided by mechanical causes.

The rust generated between the cross-stay and the sides of the link will be more or less washed out by the surge of the cable; a sufficient longitudinal stress would cause the virtually unstayed link to collapse on the stay; the sea-water would again search out the chinks; would again decompose the material; and the deterioration of the cable thus chemically and mechanically weakened, would progressively advance in successive increments that would render its ultimate destruction a mere matter of time. This action would be, of course, more felt in a cable in constant use, such as those of the Honourable the Corporation of the Trinity House; and whether zincing, which is stated by Dr. Parry to prevent rust, would be of any use, or whether other means, which will doubtless occur to many here, might prevent, or at least modify, this action, is perhaps a question worthy of investigation by the able men comprising the Trinity Board. There is, however, no need to search amongst the mysterious forces of nature for the main cause that leads to the ultimate destruction of a cable, or of any other application of iron, under like conditions. The primary cause of the destruction of a cable is simply due to the limit of elasticity of its material being exceeded. All chains are, by their very structure and special uses, subject to jerks and shocks; any country blacksmith knows that a chain that can stand a dead pull, would give way under the same weight if suddenly applied; and we all know that a careless labourer at the winch-handle of a crane sometimes breaks down a good chain by a heedless jerk. Little more than 5¼ tons to the square inch, if suddenly applied, would at once bring on the proof strain of 11·46 tons; and although the dead weight of a cable is its great safeguard —so much so, in fact, that if the cable out of the hawser could be weighted at different parts of its length, this would be an advantage—yet, nevertheless, the safe load of about 2¾ tons, under an impulsive stress, to the square inch, must be often exceeded in practice. The safe load under an impulsive stress is in truth rather less, as the assumption is based upon the usual notion, which assimilates a cross-stayed link to a couple of bars.

It appears a paradox to say that the chain is, in one sense, strengthened by a strain in excess of the elastic limit, but such is the fact. The power to bear a static load is indeed increased, as was shown by the experiments cited, before the Committee of 1860, to prove that a cable is strengthened by being broken several times under the gradually applied load of the hydraulic press; and, as was also shown by the performances of the 1⅝th bars subjected to the same treatment by Mr. Loyd. The link is, in the first place, mechanically strengthened by being drawn into a lozenge-like shape, as the two sides of each end then act as ties to a very short beam; but this is obtained at the expense of the elasticity of the material—the material of the link is rendered harder. It is a somewhat fanciful analogy to compare the limits of elasticity and of rupture of iron to the organic life of a plant or animal, but it is justified by the common expression that a bar is said to be crippled by an undue strain. If this living force in a bar—these *forces vives de resistance*, as they are termed by Poncelet—if, in one word, the work to be done in stretching a bar be expressed (in the English way shown by Mr. Mallet) by multiplying half the static load in pounds required to stretch a bar one foot long and of one-inch cross-section to its limit of elasticity, by its elongation in terms of a foot (T_e); and if the static load required to break the bar be expressed in the same way—by multiplying half the static load in pounds by the ultimate elongation in terms of a foot (T_r)—we shall then get the power for work expressed in foot pounds, or the structural value of our bar, and shall see the reason that a chain may be crippled for any application in which it is subject to an impulsive force. The short range, multiplied into the high static load required to stretch a bar of hard iron to its limit of elasticity, compared with the product of the long range but low static load required to stretch a bar of soft, ductile iron, will show that a link made of hard, brittle iron will keep its shape much better than one made of soft, ductile iron. A calculation of the work done in rupturing a bar of soft iron will show that its living force of resistance to rupture is several hundred times greater than the force required to alter its elasticity; and a similar calculation of the work done in rupturing a bar of hard iron will show that the work to be done in breaking it is perhaps twenty times less than that in stretching it to its elastic limit. As any impulsive force is equal to twice the work to be done in producing or consuming it, and as the effort required is less as the distance gone over is greater, it will be seen that, although resilience is a *sine quâ non* in a cable, the strength of the links would be destroyed, and the structural flexibility of the whole cable would be injured, by the use of iron too soft; while the use of very hard iron in the first instance, or the ultimate hardening of any iron when its limits of elasticity are exceeded, renders a cable of hard or hardened iron utterly useless for its intended purpose.

There is thus no necessity to have recourse to any theory of the crystallization of iron under impulsive stresses to explain the gradual deterioration of a cable; but this question of crystallization is one of the greatest importance and interest; and we may yet learn that the structural value, for many purposes, of a given bar of iron is in some determinate relation to the size of the facets of the crystals of which it is composed. A good cable bar consists of crystals that have been more or less elongated while passing through the rolls; the question is whether these crystals are loosened or separated at their planes of cleavage, or whether the crystalline axes have been transposed, under the undue strains, more or less accompanied by vibration, to which chains in general, and chain-cables in particular, are necessarily subject. There is no well-ascertained instance of any alteration of this kind happening under moderate stresses, but Mr. Mallet appears to believe that a reversal of the crystalline axes takes place when the elastic limit, either of extension or compression, and therefore of flexure, is exceeded, and more especially if the piece be not initially in a state of molecular repose. There is every reason to believe in the existence of internal strains in the link of a chain, and more especially at the crowns. But numberless experiments by Dr. Rankine and others, and more particularly by Mr. Kirkaldy, have shown that what is popularly called a crystalline fracture may be given to the most fibrous piece of iron if it be broken under a suddenly-applied load—an effect simply due to the mechanical effect of a sudden stress, and to the fact that any piece of iron is an assemblage of crystals. There is no reason to believe that a magnifying glass — as was, indeed, shown by Robert Stephenson—would reveal any material difference between a bar broken after fatigue of whatever kind, or a bar broken when fresh from the mill. At the same time, the application of a very powerful miscroscope to the molecular structure of iron has yet to be made; and the history of the first application of the telescope to a very different science may yet find its counterpart in this department of physical knowledge.

Whatever be the internal effect of the lateral contraction induced by excessive tensile strains, it would be of the utmost importance to settle, once and for all, whether re-annealing can restore the living force of resistance of iron, and, therefore, of a cable. Mr. T. M. Gladstone, C.E., recommended this plan before the Committee of 1860. Mr. Smale, then of Woolwich, said that this would be like Burnetising rotten wood. Dr. Noad, in a letter to the *Times*, about eight years ago, stated that he had taken away the brittleness of an old chain by keeping it for 24 hours in a furnace. The late Mr. Glynn recommended that a crane chain should be annealed every three years. At the North Roskear mine, in Cornwall, it is stated by M. Moissonet that the pit-chains are withdrawn from the shaft after every six months' use, are rolled in a heap, then covered with a sort of cylindrical furnace, and brought to a red heat. According to an account translated

from the Russian into the *Polytechnisches Centralblatt*, the chain cables for the Russian government, after being brought to a dark-red heat immediately after testing, are then tarred—a plan which is said to prevent rusting, as the tar thus takes a firmer hold on the iron. But many things may be done with charcoal iron that it would not be safe to attempt with our ordinary iron. Baudriment appears to believe that all metals only acquire determinate qualities by proper annealing, and that a cherry-red heat is necessary for annealing wrought iron. According to the experiments by the Franklin Institute, wrought iron is perfectly annealed at a clear bright red. The experiments of both Baudrimont and the Franklin Institute show that the ultimate tenacity of iron is considerably diminished by annealing, but, unfortunately, in neither case was the elongation noticed. Poncelet has shown that his co-efficient, T_e, of elasticity is increased with annealed iron, but that the co-efficient of rupture, T_r, is diminished. This refers to wires, and no complete experiments appear to have been yet made on the effect of annealing on bars. It is a question whether the extra ductility conferred on the links by the process of annealing would not, while rendering them more ductile, at the same time lead to their changing their form. At any rate, at least some of the cast-iron cross-stays would be rendered less able to withstand distortion. At the same time, the question ought to be settled, and to cables comparatively uninjured by corrosion, the process might prove of great value. The conditions of size in a cable are peculiarly favourable to the use of annealing. Great as the advantage would be in the successful application of annealing to large forgings, there are several well-authenticated instances of massive crystals being developed in the interior of the mass by the long-continued action of a red heat. General Morin thus mentions an instance of the production of crystals, with facets from 4 to 5 millimetres in breadth, in a charcoal iron bar originally of fine, soft, fibrous, texture.

Tied as we are in testing cables within a narrow limit, which if exceeded in either direction would, on the one hand, either impair the efficiency of the cable, or, on the other, the efficiency of the test, it is clear that the most thorough accuracy is required in measuring the proof stress. Unfortunately, it is not always the case that this accuracy is obtained. The stress exerted by the machine of M. David, of Havre, was shown by the French government to be taken too high. The appliance for the measurement of the stress exerted by the Liverpool corporation testing machine, was a few years ago shown by Mr. Mallet to give a result of nearly 9½ per cent. error in excess. Some of these machines consist of a powerful windlass purchase, but we will confine our attention to the direct-acting hydraulic press, the application of which to the testing of chain cables, by the late Sir Samuel Brown, may be said to have rendered the iron cable a practicable thing. There are three distinct ways of measuring, or at least approximately measuring, the stress exerted by the press plunger. 1st. A small valve is fitted to the cylinder and furnished with a steel-yard and adjustable weight. In large machines this is, for the sake of convenience, carried to a distance from the press, the water being conveyed in a small pipe. 2nd. A Bourdon gauge is attached in the same way, either direct on the cylinder, or it is placed in communication therewith by means of a small pipe. 3rd. The other end of the chain being tested is attached to the head of a bent iron lever, the power of which is multiplied by a system of levers balanced on knife edges. The plan of measuring the stress exerted by the press plunger, by means of a weighted valve, is liable to several objections, as was pointed out many years ago by Professor Peter Barlow, more recently by Professor Rankine, and by Mr. Bowman in his evidence before the 1860 Committee. In the first place, the relative proportion between the pump plunger and the valve is necessarily great; and a simple calculation will show that a hair's breadth more or less to the valve would make an important difference. In the next place, the friction of the leathers and the weight of the plunger are not taken into account; the gross load on the plunger is, in fact, given as the useful work at the end of the piston rod. Some experiments made by Professor Rankine, whose name is a sufficient guarantee in matters of this kind, have shown that about one-tenth should be deducted from the pressure in the hydraulic press, merely for the friction of the press plunger. The real, the useful work exerted at the end of the plunger on the chain is thus more than 10 per cent. less than is given by the pressure of the water. An error in the opposite direction will be made by conducting the pressure of the water, either on a weighted valve, or on a Bourdon gauge, and this error will vary with the diameter of the pipe, the number of bends, and the other losses of effect in a stream of water passing through a pipe, which are well known to engineers. The load on a safety valve is always an unreliable datum for computing pressure; a Bourdon gauge is much more delicate, but, in this case, its indications are erroneous, unless proper allowance be made for the friction of the leathers and the weight of the plunger. The most exact means yet employed for measuring the stress created by the plunger on the chain, consists in the use of a system of balanced levers, according to the plan adopted at H.M. Woolwich and Portsmouth dockyards, and by Messrs. Brown and Lenox. The press at Woolwich is also furnished with a weighted valve, according to the plan just mentioned, and in addition to the system of levers. The lever scale is perfectly sensible to a few pounds, but the valve scale will scarcely move with a load of two tons, and it is less and less sensible as the loads increase. The balanced levers are perfectly accurate, but the apparatus is rather expensive. At the last Worcester Show of the Royal Agricultural Society, a certain apparatus (not patented) was exhibited for testing the draught of Fowler's six-furrow steam-plough, and it appears to me that a modification of this dynamometer might be employed for registering the stress on a cable. It consisted essentially of a cylinder, and a piston, on one side of which was a volume of water in communication with a Bourdon gauge. The water was enclosed in an elastic diaphragm, fixed to the piston and to the cover, and the gauge was necessarily marked according to the results given by weights gradually applied. By shrinking rings on the outside, or by straining on a coil of wire, the cylinder could be made to stand any amount of pressure required, and, if adjusted with the cross shackle pins at the opposite ends, at right angles to each other, in order to prevent any torsion, and also by the adoption of other simple means, such as the use of steel, that will occur to those now present, a light instrument of probably very great delicacy would be obtained.

When a long length of cable, say of seventy-five fathoms, is being tested, there is another influence that will, in some cases, affect the result. If we take the comparatively light one-inch cable, we find that it weighs 58lbs. per fathom, so that the whole length will weigh nearly two tons. The last link at each end will have to stand a down pull of nearly one ton in addition to the longitudinal stress of 18 tons. This, however, would probably be practically compensated by directing the hammer test more towards the centre portions of the cable, and the *vis viva* of each blow will be absorbed by the elasticity of the metal, the deflection of each link struck, and by the combined weight and resilience of a certain portion of the cable within the range of each blow. It may here be noticed that in testing the effect of impact on beams, Mr. Hodgkinson used a 4lb. leaden cushion in order to partially deaden the jar of the blow. In a leading article of one of the engineering journals, in May last year, giving an account of Lloyd's proving house, it was proposed that "a falling weight, to be released by a trigger tripped by a long cord," should be employed instead of the hammer, in order to prevent any accident to the operative, through the flying of the cable or a chip of the cast iron cross-stays. This weight could be made to slide overhead in the same vertical plane as the cable; and by letting it fall from heights

determined for each diameter of cable, the *vis viva* employed could be measured with approximate accuracy. This would only be on a par with the plan adopted in numberless instances, as we have seen, by our scientific neighbours the French; and similar measures might perhaps be used to measure the blow required to carry out the fracture test.

The application of known impulsive force as a test is of the utmost value, more especially when, as with cables, the object tested will have to undergo such forces in practice. If some plan could be devised for easily and accurately submitting the whole length simultaneously to a sudden instead of a static load, this would be of great importance. In the mean time, the hammer-blows are the tests for the resilience of the cable. In doubtful cases Professor Daniell's acid test might be of value in examining the structure of the fractured sections of the two or three links that are usually broken up. A great number of experiments on the specific gravity of iron have shown that it would be dangerous to make deductions as to the qualities of a specimen of wrought-iron worked by one metallurgical process, and to then apply these results to a bar produced by another mode—for instance, to compare in this way a rolled bar with a hammered bar. At the same time there is a remarkably close, though not perfect, correspondence between the specific gravity and the quality of the specimens. Mr. Kirkaldy found that the specific gravity of iron was even decreased by being much strained—at any rate by tension. It is very easy to obtain the specific gravity of any substance like iron; and whether the physical facts that, 1st, the gravities cf, for instance, No. 3 bars, bear a pretty constant relation to their qualities; and that, 2nd, the specific gravity of wrought-iron generally is diminished by tensional straining; and, 3rd, that it is considerably increased by annealing, might be used in practice for testing the quality of the iron, or the deterioration through wear of a chain, is at least worth an inquiry.

The physical conditions involved in the construction, the use, and the testing of anchors, differ so materially from those of chain cables, that the two subjects must be separated in an examination of this kind. But there can be little doubt that a sound and general system of testing the mooring tackle of ships will bring about the same improvement in the quality of chain cables and anchors, as the trials at Shoeburyness have already effected in the quality of rolled plates; and the effect will indeed be produced by somewhat similar causes.

DISCUSSION.

Mr. T. M. GLADSTONE, (Superintendent of Lloyd's Proving House, at Poplar,) said he had had considerable experience in the subject which had been treated of by Mr. Paget in so elaborate a manner. There were, however, one or two points on which he differed from that gentleman. Mr. Paget had stated that the crown was the weakest point in the link of a chain. Now if that were so this would be the point which would usually give way in the breaking of a chain, but in the course of his experience, extending over a period of 30 years, and having the superintendence of Lloyd's testing machine, he had not found that this was the case. [Mr. Gladstone exhibited some specimens of links broken under the testing apparatus, showing the fracture to have occurred on the side of the link.] The next point on which he ventured to differ from Mr. Paget was the statement that the breaking strength did not indicate the quality of the iron. Now, he did not know anything which more completely determined the quality of iron than the ultimate tensile strength, except, of course, when converted into steel, the tensile strength of which might be much greater than that of iron, but it might be unfitted for the purposes of a chain cable owing to its brittleness. If they struck it suddenly with a hammer it would break like glass. Then as to the question of injury to iron by testing, if they could make a certainty of having a chain of the finest quality, both in material and workmanship, there was no question it would be most desirable not to subject such a chain to the process of testing; but this became a necessity, inasmuch as in the absence of certainty as to the workmanship and material, they were obliged to subject the article to some test. The late Sir Samuel Brown ascertained by numerous experiments what was the proper test to apply to chain cables; and he (Mr. Gladstone), humbly following in the steps of Sir Samuel Brown, could corroborate his conclusions. He decided that 650 lbs. to a circle one-eighth of an inch in diameter was the proper strain to apply. There were on the table some specimens of links $1\frac{1}{2}$ inch in diameter, which had been broken that day by Lloyd's machine. The Admiralty proof was $40\frac{1}{2}$ tons, but the chain stood the strain of $59\frac{1}{2}$ tons, and then separated, the iron being perfectly sound, and of fine quality. That, he said, showed that the Admiralty test was not such a test as would at all distress a properly manufactured cable. The value of the proving was this, to show that common iron would not stand the Admiralty test. No. 2 iron would stand the merchant service test, but would not stand the Admiralty test. Sir S. Brown's test put a stop to the use of inferior iron, and therefore was most valuable. Reference had been made in the paper to the evidence of Mr. Bowman, given in 1860, that he desired a higher test, but he (Mr. Gladstone) thought that whereas No. 2 iron would not stand the Admiralty test, they had a tolerable warranty that no inferior iron would be passed. In the manufacture of a chain, the great difficulty was, with careless workmen, to get a perfect weld. He knew instances in which A1 ships had been provided with chains the welding of which had been imperfect from the first; and when he told them that in the last half of 1863 there were 32,000 fathoms of chain tested at Lloyd's machine, and that one-fourth of those were imperfect, and that 2,000 fathoms were completely condemned, it showed how very lamentable was the state of the chain cable manufacture in the merchant service. Mr. Pope, however, had said, in 1860, that the test was too high, but he (Mr. Gladstone) would abide by Sir Samuel Brown's experience. With regard to the influence of temperature—so far as testing in the machine was concerned, the temperature was a matter of small importance, in his opinion, although in the royal dockyards a standard temperature was adopted. With the machine at Poplar he could test seventy-five fathoms of chain in five minutes from the time the machine was put into operation. The action of the test upon iron was to raise the temperature, and if they put the thermometer to it they would find that in proportion to the strain the heat would increase very rapidly, so that at the time of fracture the iron became too hot for the hand to bear. The mere difference of temperature from zero up to the ordinary temperature in this country would be overcome in five minutes by the action of the strain upon the iron, but if a sudden jerk came upon it the temperature was then an important condition. Mr. Paget had referred to the difference between the strength of iron in the direction of the fibre, as compared with the cross grain. He (Mr. Gladstone) was now making boat plates, and, in order to meet this objection, there had been introduced a kind of weaving action in the rolling by passing the plate through the rollers first in one direction and then in another. With regard to the retesting of chains after use, he considered it was valuable in some respects, but it required to be done with great care. It was, however, desirable to know what the value of a chain was after a series of years, and this would only be ascertained by retesting. If a chain had been exposed to much wear, it was often desirable that it should be reannealed to renew its elasticity. Mr. Paget had made a rather warm attack upon the hydraulic press process of testing, and maintained it was not so good a machine for the purpose as the lever. He (Mr. Gladstone) had had a good deal of experience with the hydraulic press, having one of 300 tons power

under his superintendence, and he could state that the total amount of friction that applied to it did not amount to more than eleven cwt., and that amount was constant, because, when once they overcame the effect of the friction of the leathers there was no difference whether they had 300 tons upon it or one ton. Mr. Paget had stated that the error as compared with asteel-yard was two tons, which, if it were the fact, would alter his opinion as to the value of the hydraulic system as applied to testing machinery. Mr. Paget had further stated that in testing a chain 75 fathoms long, one inch in diameter, inasmuch as it weighed two tons, there was a material difference in the strain between one end and the other. It was true, if they suspended a chain of 75 fathoms, the link that held the weight of two tons had two tons more than the link at the other end, but if they laid the chain horizontally and supported it on rollers every 15 fathoms, and then put a strain upon it, there was no appreciable difference between one part of the chain and another. He had practically tested this question, and had found this to be the case. Sir Samuel Brown had been named as the introducer of chain cables, but he (Mr. Gladstone) found that they were used in much earlier times, being mentioned by Cæsar, in his history of the Gallic war. He had made considerable observations as to the corrosion of chains, &c., by the action of sea-water. He believed that was an element of great moment in the deterioration of chains, but he had often seen that a chain was more injured by rust, when laid by in the locker of a ship than when in use. Wrought iron was more easily oxidised than cast iron. The latter would last three times as long as the former in the shape of rails. The cast-iron railing round St. Paul's, though it had stood upwards of 150 years, showed but little deterioration, while he had seen wrought iron railings reduced almost to nothing in a comparatively short time.

Mr. FREDERICK LAWRENCE agreed with Mr. Gladstone in his opinion that the crown of the link was not its weakest part. It was not the weakest place when the chain was made, but it became so after the chain had been in use for a length of time. The crown of the link was where the wear took place, and if a chain were tested after it had been in use, he believed the link would break at the crown. He was inclined to think the Admiralty test was too high, and the examples brought before them by Mr. Gladstone were evidences that this was the case. The Admiralty test of a chain like that on the table was 40½ tons; 59½ tons were applied to it and it broke. Thus they had been straining the chain with 40½ tons, when it would break by putting 19 tons more upon it. He had no hesitation in saying that, in testing that chain to 40 tons, they injured it, without any advantage being gained. He believed the proper test for wrought iron should not exceed eight tons to the square inch. If chains were proved to that, it would be all that was necessary to ensure safety. It was not perhaps generally known that manufacturers of chains made their workmen answerable for a faulty one, and if a chain was defective in workmanship the workmen were not paid for the making of it; so that the knowledge that the chains would be tested made the men careful to see that the welds were well made. It was wonderful that chains did not break more often, when it was borne in mind that in a long length of chain there were such an immense number of welds all depending upon the skill of the workmen, and that the slightest burning of the iron, and the slightest fault in the welds rendered the chain liable to break. He thought to put too high a test on a chain was not wise. He believed so high a test was of no use as a security, and was, moreover, injurious. That chains should be tested there could be no question, and he thought it of importance that the chains of merchant ships should be tested at regular authorised places. He did not say they should be subjected to so high a test as the Admiralty standard, but there should be some test to prove that a good chain had been supplied. There was nothing so bad as a cheap chain; and owners of ships were sometimes led to practise a false economy in that respect, because a cheap chain meant cheap iron and cheap labour, which were synonymous with bad iron and bad labour.

Mr. SHIPTON said, having had the privilege of witnessing a great many of Mr. William Fairbairn's experiments, he differed entirely from the last speaker in fixing the limits of the test at eight tons to the square inch. The experiments of Sir William Brown through a long series of years had led to the adoption of what was now the Admiralty test, and, therefore, he could not see how the limit could be fixed at eight tons, because manufacturers, in regulating the quality of their iron, had gone so near to what would just stand the Admiralty test, that a lower standard would lead to the use of iron of a very inferior quality.

Mr. LAWRENCE explained that the reason why he fixed upon eight tons to the square inch was, that it was known that the breaking strain of good iron was about 24 tons to the square inch, and he thought that the test should not exceed one-third of the breaking weight. More than that he believed tended to injure the chain. He thought besides this test, the quality of iron in a chain should be ascertained by testing some of the links to their breaking strain.

Mr. GLADSTONE added that he started with the proposition, that if they could rely upon the quality of iron and the workmanship, no test would be necessary. But, owing to the competition that existed in the chain manufacture great depreciation had taken place in the quality of iron, as well as in the workmanship; and, therefore, to provide against an admitted evil, there was a necessity for testing to a given point, and he had endeavoured to show that the standard arrived at by Sir Samuel Brown was the proper one.

Capt. SELWYN, R.N., thought the gallant chairman, distinguished as he was in the profession to which he belonged, would allow him to say, on behalf of that profession, how immensely important the question of good chain cables was, and how vast was the responsibility which attached to the chain manufacturer in such matters. In it were merely a question of property, that would have some influence, but when the lives of a large ship's crew depended on the quality of the cables produced, the responsibility of the manufacturer was largely increased. In the matter of tests, it appeared to be lost sight of that all tests, whether of guns, bridges, or railways, were carried much beyond the strain they would ever be called upon to bear in actual use. As much as 14 bullets and 16 drachms of powder had been used in testing a rifle made of Bessemer's steel; why, therefore, should chain-makers complain at being subjected to the Admiralty test? Would it not rather be wise on their part to endeavour to improve the quality of the iron they used, thereby diminishing the weight of the cable, by the use of a better quality of iron, or that modified iron manufactured by Mr. Bessemer. There was no security with such a test as eight tons. If a chain bore this it might break at twelve or sixteen tons. With reference to this subject he would draw attention to a system patented by a Spanish lady, which was shown at the Exhibition of 1862, and which, he had been informed, was under trial at one of the dockyards. In this system steel was employed for chain cables instead of iron. Thin plates of steel were put together to form the link, and afterwards immersed in a bath of metal, which made them impenetrable to the action of salt water. Steel, when drawn out into wire, gave a tensile strength of something like 136 tons per square inch, whilst the bar of steel from which it was drawn would only bear 56 tons. The appearance of the fracture of wire always showed them that the principal part of the strength of the wire resided in the outer crust, hardened by the process of drawing. He thought Mr. Paget had been misunderstood by some gentlemen in speaking of the strength of a cable. He did not mean that the crown of the link

was where the cable would break, because the strain did not come so directly upon it at that point, but merely that this was the part of the link that was necessarily the weakest, owing to the state of tension that the bending of the iron produced. With reference to the tension brought on chains, the chairman would agree with him that usually the amount of cable out was so great that the last few fathoms next the anchor lay on the bottom, and so the full force of the strain was never felt. There was in fact a spring-like action, so that no sudden, impulsive strain was put upon the cable. The hydraulic press, therefore, in a measure, did meet the required conditions of test, and therefore it appeared to him the most fitting machine that could be employed. It would be better if they could make the test under the same conditions of catenary strain, but that was practically impossible. He would mention that during the time he was serving under the command of the chairman, it became necessary to moor the ship on the equator for the purposes of survey, and she was moored in 60 fathoms water with two bower chains, and so great was the strain in heaving up those two cables, that the hawse pipe was cut through, but the cables stood as no cable could have been warranted to do if the test had been diminished to eight tons.

The CHAIRMAN said that in his experience he had not observed a chain cable part at the crown of a link; the rupture also more frequently occurred near the anchor than at the hawse holes. As regarded the observation attributed to Mr. Loyd in relation to breaking and rewelding bars—proving that they were stronger after welding, he considered that good welds should produce this effect. The iron at this point received special treatment—it was "jumped" for the weld and hammered to a better surface. As to the dates at which chain cables were used in the navy, his experience went back as far as 1815. They were used at Algiers in 1816, in Arctic service in 1825, and on the coast of Africa in 1830-33. He had occasion to moor his ship with very taut cables, and they had experienced much abrasion within the crowns of the links from constant service. But the greatest damage to chain cables resulted from galvanic action by the chain coming in contact with the copper on the stem; and he recollected a case at Rio Janeiro where the officers of a ship in which the bridles were kept taut against the stem, reported that the furrows resulting from this were eaten by the rats. This, he need hardly say, was owing to galvanic action. With reference to iron becoming brittle by intense cold, he recollected, as a boy, when skating at very low temperatures, the skates broke like glass. As to the fishermen using hempen instead of chain cables, that resulted from the impossibility of holding cold iron at low temperatures, but, as a rule, iron below water could not be subject to a lower temperature than 28·5°, when the atmosphere might be as low as — 62°. With regard to testing cables, he was of opinion, from the causes to which he had alluded, that all cables should, particularly if used in copper-sheathed vessels in tropical climates, be proved on the return of the vessels to this country, as one faulty link might lose ship and crew. With regard to the strength of steel cables, the late invention of drawing steel tubes cold, without impairing the texture or tensile strength of the material, proved its great tenacity. He was sure that all present would unite in a cordial vote of thanks to Mr. Paget for his valuable paper.

A vote of thanks was then passed.

Mr. PAGET, in acknowledging the compliment, stated that a reference to his paper would show that Mr. Gladstone's remarks corroborated its substance, and, as he had the greatest respect for Mr. Gladstone's abilities and experience, this gave him great satisfaction. It would be seen that though he (Mr. Paget) showed that the link was *theoretically* weaker at its crown, nevertheless, the practical contingencies of welding rendered one of the sides practically weaker. As an experienced workman, he was well aware of the uncertainty of welds. In stating that a steel bar, which might have an ultimate breaking strength much higher than a similar wrought-iron bar, might, nevertheless, be unfit for a cable, Mr. Gladstone corroborated his (Mr. Paget's) assertion that the ultimate breaking strength *alone* was not the true indication of the value of any material of construction. Other remarks by Mr. Gladstone favoured the same views. In the same way Mr. Gladstone appeared to believe that the Admiralty test, if often repeated, would diminish the value of a cable, or at any rate a per-centage of ordinary cables, and he (Mr. Paget) had been careful to point out that the test could not be too high for the welds alone, while, for the iron, it ought to be confined within its limit of elasticity, and that the present Navy test was probably the best. He (Mr. Paget) did not venture to express a distinct opinion as to the influence of frost on iron, but he had stated that iron was heated in the very act of straining it. The question was:—Did the strain, or the internal friction thereby generated, sufficiently raise the temperature of the chain to allow it, *cœteris paribus*, to scathlessly undergo the percussion of the hammer test? Mr. Gladstone had stated that doctors differed, and, without laying claim to more than student's rank, he ventured, with every respect for Mr. Gladstone, to differ from him in his mode of estimating the stress practically exerted by the press plunger. Just as an indicator diagram cannot be taken by placing the indicator on the steam-pipe, so allowance must be made for the consumption of work, in moving the plunger, in the friction of the leathers, &c. The question between himself and Mr. Gladstone was:—Did the friction increase, or did it not increase, with the pressure of the water? Mr. Paget ventured to refer to the known general laws of friction as corroborating his assertion; to the special experiments on hydraulic presses by Dr. Rankine; and to the ocular demonstration as to the relative value of the two systems of measurement, to be seen in H.M. dockyards. The paper he had had the honour of laying before the meeting was simply an application of known practical engineering principles to the testing of chain cables; he (Mr. Paget) fully saw its shortcomings, which were, leaving out any other cause, in a great measure due to the comparatively provisional state of science bearing on the strength of materials. As the paper was intended to treat on the testing alone of cables, he did not consider it necessary to reply to the extremely interesting observations of some of the speakers on the practical working of cables.

Proceedings of Institutions.

HULL YOUNG PEOPLE'S CHRISTIAN AND LITERARY INSTITUTE.—The fourth annual report congratulates the members on the position of the society. The income amounted to £360 16s. 6d., and the expenditure to £326 12s. 8d., leaving a balance in favour of the Institute of £34 3s. 10d. In addition to this there was a small income arising from other sources, making a total of £40 19s. 10d., which would go towards the reduction of the debt. The lecture course had been greatly more self-supporting than in previous years. The income of the library amounted to upwards of £50, which was very considerably more than in any former year. The special lecture, for the benefit of the library, had realised £34 14s. The total number of issues was upwards of 14,000, which was unprecedently large. The total number of books at present was 889; increase for the year, 105 vols. It having been resolved to admit lady subscribers to the use of the library, the committee were making renewed efforts to increase the number of books, and they recorded with great pleasure a valuable gift of fifty volumes, standard works, recently made by the president, W. Irving, Esq. This donation was to be made the nucleus of a further increase. The committee also acknowledged a valuable present from Admiral Fitzroy, of maps and charts illustrative of the principles on which his forecasts of weather are founded.

The classes in connection with the Institution were, the Sunday Bible class, weekly discussion class, German, French, and short-hand classes. The annual excursion had been very satisfactory. The cricket club maintained its previous character as a most interesting feature of the Institute. The committee had been disappointed in the hope of obtaining new premises. They had been compelled to decline the site opposite the present building, and no other suitable one had been met with. The committee had to regret the departure of the late secretary, Mr. James Sibree, to Madagascar. The best wishes of the society followed him thither. The number of members was about fifty less than last year. The total number was about 1,100. The diminution was apparent rather than real. A discussion took place at the annual meeting on a proposal to alter the name to "The Christian and Literary Institute." The motion was negatived by a large majority.

YORKSHIRE UNION OF MECHANICS' INSTITUTES.—The annual meeting of this Union is to be held on Wednesday the 18th May, Sheffield being the appointed place this year. The proceedings commence with a conference of delegates from the several Institutes in the Union, at which some interesting subjects undergo discussion, Mr. Edward Baines, M.P., the president of the Union, being the chairman. In the evening there will be a public meeting, at which his Grace the Duke of Argyll, K.T., Lord Privy Seal, will preside, and it is expected that the meeting will also be addressed by several distinguished friends of popular education, including Mr. J. A. Roebuck, M.P., Mr. Baines, M.P., Mr. Harry Chester, vice-president of the Society of Arts, Mr. Thomas Dunn, the Rev. Canon Sale, and others. The committees are actively engaged in making the necessary preparations, and on the following day, which is usually devoted to recreation, there will be an excursion to Chatsworth, the seat of the Duke of Devonshire.

Fine Arts.

RECENT SALES OF WORKS OF ART IN PARIS.—Many important collections have recently been dispersed by the hammer of the auctioneer. The sketches and drawings by Prud'hon, bequeathed by the painter, who died in 1823, to his friend Monsieur de Boisfremont, attracted great attention and deservedly so. The sketches exceeded two hundred, and several of them had never been carried into execution as finished pictures; but the studies after nature obtained most attention, fetching from four to eight hundred francs each. The growing taste for the works of Prud'hon, as compared with those of his great but meretricious rival, David, is one of the best signs of the progress of artistic feeling in France. At a miscellaneous sale, which occurred last week, a painting of a vase of flowers by Delacroix fetched £83, and another, the "Education of the Virgin," £88, while a drawing by the same author, in pastel, the "Education of Achilles," realized £50; and an oil painting by Ary Scheffer, the "Temptation of Christ," £256. At the sale of the collection of Dr. Van Cleef, of Utrecht, which occurred here, some fine pictures were disposed of. "Players at Bowls," by Jan Steen, fetched £134; "Three Cows in a Meadow," by Paul Potter, £116; two bouquets of flowers, by H. Upping, £140; "A Peasant leaning over a Half-hatch door," by Adrian Van Ostade, £65; portrait of himself, by Rembrandt, £80; and the "Master of the Vineyard," from the parable of Christ, by the same, £1,012; "The Cradle," by De Hoogh, £36; "Saltimbanques," by Philip Wouvermans, £148; and a Claude, "The Entrance of the Port of Ancona," £600. A most interesting collection of drawings by Albert Dürer, the property of Comte Andréossy, was dispersed by the hammer, the prices being exceedingly high. The following are some of the most remarkable:—A pen and ink drawing, heightened with white, of Christ in the tomb, signed and dated 1495, £41; portraits of German séigneurs, same style, dated 1521, £58; a drawing, 1520, of Adam and Eve, £100; a young man on horse-back, with a lady behind him, dated 1508, £44; and fine sketches of flowers and animals on vellum, signed and dated 1508-21-23-26, £69 8s.

Manufactures.

MUSEUM FOR INVENTIONS.—Mr. Dillwyn called attention in the House of Commons on Friday, the 29th April, to the insufficiency and inconvenience of the temporary Museum for Inventions at South Kensington, and the Patent Office in Southampton-buildings, and to the expediency of uniting the Museum for Inventions and the Patent Office under one building, and at a convenient distance from the law courts. He then went on to say that the Patent Office possessed the nucleus of an excellent musem of models of inventions, but that the South Kensington institution was not the proper place for them. The models were thrown together at Kensington in such a manner that nobody appeared to take the least interest in them. But, bad as the models and inventions were, the Patent Office library was in a worse state; for, owing to the smallness of the space, the books were stowed away in nooks and corners; and there was not sufficient accommodation for readers. He objected to a library of this sort being sent to so distant a place as Kensington, and thought that both the library and the models of inventions should be removed to some suitable building in the vicinity of the courts of law. His objection to the site at South Kensington was, that it was too far away for the working classes, and from the centre of the metropolis. It was said to be exceedingly difficult to get a site near the centre of the metropolis. He had been told, however, that an adequate site was easily attainable in Chancery-lane, and he felt sure that would be a much better locality than South Kensington for the museum. —Mr. Gregory asked whether the Patent Commissioners were agreed that the museum should be at South Kensington; for if so, they had changed their minds within the last year and a half. In their report of 1862 they stated that the office, library, and museum should either be under the same roof, or at least contiguous to each other; and another consideration which they urged was, that all three should be in some central spot. He also wanted to know whether the Patent Commissioners had been consulted in the matter, and whether they considered South Kensington a central site.—Mr. Cowper admitted that the Patent Office in Southampton-buildings was at present very conveniently situated, but that the accommodation for the library, &c., was by no means adequate. Up to 1853 the building was sufficient for the public wants; but the library had since increased so rapidly that the building was no longer commensurate with the demands upon it. The necessity, therefore, for increased accommodation had been pressed upon the Government and upon the commissioners; but, as the Patent Office ought to be in the legal quarters that were close to the inns of court, there was extreme difficulty in finding sufficient accommodation. They, however, had in view a building in that neighbourhood, which would be amply sufficient for the purpose of an office and library. There was, however, no possibility of placing the museum under the same building; and indeed the museum had never been connected with the Patent Office. Last year, when the Government were asked for what purpose they recommended the purchase of the site at South Kensington, they explained that they did so because, among other reasons, it was well suited for the patent museum. He had therefore invited public competition for the erection upon that site of a building capable of containing the patent museum and the natural

history collection. Of the two sites he thought South Kensington quite as approachable for the working classes as Chancery-lane. But, at any rate, the commissioners recommended that, for the present, half an acre should be devoted to the museum, and hereafter a much larger space than that. It would be impossible, however, to find that large space in the vicinity of the Patent Office, and that was a strong reason for availing themselves of the site at South Kensington. He could not point to any clear statement of the commissioners favouring the removal to South Kensington, but he believed they would be satisfied if complete space were found for the purpose.—Colonel Barttelot protested against the supposition that the House, by its vote of last year, had approved of the proposal that the museum and the other buildings should be located at Kensington.—Mr. A. Smith likewise concurred in the notion that no engagement had been entered into last year respecting the appropriation of the site at South Kensington.—Mr. Ayrton complained of the ambiguous position in which the question had been left by the Government, and hoped that it would be referred to a select committee at the earliest possible day.—The subject then dropped.

IRON, MACHINE, AND ENGINEER TOOL TRADES.—The April report of the Leeds Chamber of Commerce states, that during the month there has been a good demand for all sorts of iron, but nearly all the works have now ceased, owing to a dispute between the masters and men in reference to trades unions, and which does not appear likely to be soon settled. This dispute has caused several thousand men, in various branches, to be thrown out of work in this neighbourhood. The machine makers continue to be very busy. The engineer tool trade is very good, and the makers have considerable orders in hand. The makers of locomotives and railway plant are very busy. The dispute in the iron trade will not much affect these branches.

Obituary.

JAMES KERSHAW, M.P., died at Streatham on the 27th April. He was one of the members for Stockport, and head of the firm of Kershaw, Sidebottom, and Co., cotton spinners, manufacturers, and calico printers, Portland-street, Manchester. He was born in 1795, and started in life as a warehouse lad, but showed such eminent business qualities that at an early age he was made partner in the mercantile firm of Lees, Millington, and Callender, of which he became ultimately the leading partner. It was not till some years after that he became a spinner and manufacturer. As a Liberal politician he took part in most of the stirring events in Manchester, from 1830 forwards, including the Reform and Anti-Corn-Law League agitations. He was a member of the council of the League, and was a subscriber of £1,000 to the fund, and about the same time he subscribed £1,000 towards purchasing public parks for the people of Manchester. He was also a liberal supporter of schools and of foreign missions. He was an earnest supporter of the movement for obtaining a charter of incorporation for Manchester; was elected an alderman of the first town council under the charter, and was made third mayor of Manchester in 1843, holding the office for two years. He became a candidate for the representation of Stockport in Parliament along with Mr. Cobden, in July, 1847, but was defeated. In December of the same year, however, on Mr. Cobden vacating his seat for Stockport, to accept a seat for the West Riding of Yorkshire, he stood a second contest, and was elected. He continued to hold the seat till his death. He lost his only son some years ago, but several daughters survive him.

THOMAS HENRY MAUDSLAY, the well-known head of the firm of Maudslay, Sons, and Field, engineers, was born on the 16th June, 1792, and died on the 23rd April, 1864, aged about 72 years. He began to work in early life with his father, the mechanic, Mr. Henry Maudslay, in Margaret-street, Cavendish-square, whose life will be found in Smiles' "Lives of the Engineers," Smiles' "Self Help," &c. The block machinery, although first designed by Brunel, was perfected, constructed, and applied by Mr. Maudslay's father, in such a way that by the first year's use a degree of economy was effected to the extent of £24,000. Mr. Thomas Maudslay worked hard during his youth. After assisting in the construction of machinery, steam engines, &c., which required great skill, he went to France, and there fitted up machinery surpassing anything of the kind seen in that country. He fitted the Regent's-canal gates, which were curiosities at the time. He came with his father to Lambeth, and by patient investigation and a careful consideration of the "ways and means," he assisted in transforming the establishment, which was then but a bantling, into a gigantic engineering manufactory; and during the Crimean war there were no fewer than 1,200 men employed. He mainly assisted in cherishing, advancing, keeping together, and protecting an engineering establishment which could boast of bringing to mechanical perfection some of the brightest ornaments in the engineering world, including Whitworth, Nasmyth, and Richard Roberts. Mr. Henry Maudslay, very early in life, took his son, Thomas, to the well-known bank of Messrs. Masterman, Mildred, and Co., of Nicholas-lane, and for a period of nearly forty years he was the one who signed the cheques of the firm. Mr. Maudslay was chiefly, though not exclusively, a naval engineer. For the last quarter of a century and more he has constructed engines for some of the largest and some of the smallest vessels in Her Majesty's navy—from line-of-battle ships to gun-boats. His firm supplied the iron-cased *Royal Oak* (800 horse power), the *Marlborough* (800), the *Revenge* (800), the *Gibraltar* (800), the *Edgar* (600), the *Trafalgar* (500), the *Majestic* (400), &c.; the screw-frigate *Ariadne* (800), the *Immortalité* and *Topaz* (600 each), the *Aurora* (400), &c.; besides corvettes, screw-sloops, gun-boats, paddle-sloops, gun-vessels, and troop-ships, innumerable. The old *Endeavour* (on the Thames), H.M.S. *Lightning* (still in service, as among the earliest movements in steam-ships), and, since then, the *Great Western* (which is still in the Royal Mail Steam Packet Company's Service), and H.M.S. *Terrible*, must not be omitted from the list of his works. Although one of the first of the originators of the Institution of Civil Engineers, he was of a retiring disposition, and withdrew after some years, and Mr. Joshua Field, his partner, afterwards became president. Mr. Maudslay, like many other eminent men, was the architect of his own fortune; beginning life in a humble capacity, he died the wealthy owner of Banstead Park, and the head of a firm almost identified as much with the banks of the Neva as with the banks of the Thames, a firm employing more than 1,000 hands. He was elected a member of the Society of Arts in 1815, and remained so till his death.

MEYERBEER, the eminent German composer, died on the 2nd inst., in Paris. The deceased was born in Berlin, on the 5th of September, 1794, and at the time of his death was nearly 70 years of age. As a child he was extremely precocious, and his musical talent came to him so early, that when only seven years old he was celebrated; and at nine a German critic spoke of him as one of the best pianists of Berlin. Under less favourable circumstances the lad would doubtless have been prematurely brought before the public as a prodigy, to contradict, perhaps, in manhood, the promises of his youth. But his father James Beer, a Jew banker, was very wealthy, and Giacomo Meyerbeer, as the composer afterwards called himself, Italianising his name, only appeared occasionally, principally at amateur concerts, and had plenty of opportunities afforded him for study. With what result he availed himself of them is known throughout the world. Meyerbeer did not, however, at once obtain a high position in music. His first opera, *Jephtha's Daughter*, was represented at Munich in 1812 with but indifferent success,

but the numerous works he afterwards produced, and which extended over nearly the whole range of musical composition, secured for him a wide reputation, and proved that his talents were of no common order. Of these productions the *Crociato in Egitto*, produced in Venice in 1825, may be said to have laid the foundation of his European fame. In 1831 he produced his grand work, *Robert le Diable*, and henceforth Meyerbeer was recognised as a master. The *Huguenots* followed in 1836, and the *Prophète* in 1849, both operas at once taking that commanding position on the lyric stage which they have ever since maintained. *L'Etoile du Nord*, a work in a different style, but distinguished by the same charm of genius, followed in 1854, and the *Pardon de Ploermel* still more recently. It has long been known that the deceased composer had finished another work, *l'Africaine*, and that his scrupulous, and perhaps fastidious, anxiety to secure for it a satisfactory interpretation has alone kept it from the public. Its production may now, it is to be presumed, be looked for at no distant date.

Correspondence.

VACANT NICHES IN LONDON.—SIR,—You may recollect, as I do, a caricature by Gilray, called "More pigs than teats," in which the government of that day was represented as the lady pig recumbent in the straw, and the place-hunters by a whole army of little pigs, far more in number than the teats and places they sought. This is as good as one of Æsop's fables, and I suppose will live as long. It is, however, to the reverse of this tableau that I would refer, viz., to a case in which there is a superabundance of places vacant and unoccupied—to that of the many architectural niches throughout London vacant of the features they are fitted and were originally destined to hold. It is not requisite to cite instances, for a short walk through any part of London will supply plenty. A niche is evidently an incomplete feature without a vase or a statue in it, and yet I doubt whether one-fourth of the niches in the buildings of London are occupied, and this although we may be quite sure that in the original designs, submitted and approved, of these buildings they were religiously filled with sculpture. The truth is, sculpture is used as a bait in decorating architectural designs, especially in competition, but when the design is fixed on then come the details of estimate and contract, &c., and then the first thing "knocked off" is the sculpture. It is not essential, they say, to the uses of the structure, and it can be done at any time, meaning, no doubt, that it should be done at some time, but in the event it never does get done, for unexpected extras come in, and the committee are at the end of their funds. Assuredly an unoccupied niche in a building is an absurdity as well as a shortcoming, and yet there are a vast number of them in London. In some cases they afford excellent situations for statues, for the subjects of which we cannot be at a loss while the fact exists, which it does I am told now, that neither Shakspeare, Milton, Newton, Cromwell, Locke, nor a number of our other worthies have tributes of this kind in London. Now, might not this subject fall legitimately within the province of the Society of Arts to suggest and give their countenance to, viz., the completion of some of our public buildings, by thus supplying the features originally contemplated in them, and honouring some of our worthies, who, if they had been Italian, German, or French, would long ago have had this tribute accorded them; by which means also art would be encouraged? Our bridges also have many pedestals unoccupied, as also many other architectural situations in London, among which prominently stand the four great pedestals in front of the British Museum, which were intended, I am told, to receive the statues of Shakspeare, Bacon, Newton, and Locke, but there the great unmeaning blocks have now stood for years without any excuse. To fill these niches and crown these pedestals might surely meet with some response if put properly before the public; and if marble and bronze were in some cases too expensive, then iron, stone, or terra cotta afford, I believe, nearly as good art at a lower rate. —I am, &c., COMPLETE YOUR WORK.

PATENT LAWS.—SIR,—Your *Journal* has been sent to me containing a discussion on patent law. I am not much of a speaker, so wish to write a word or two in reply to certain remarks. One gentleman said that the inefficiency of patent law was shown by the number of patents that fall through—a mere per centage passing the crucial test of public ventilation at the three and seven year stages respectively. As he spoke with vigour and fluency, let me ask the serious attention of the members and debaters on this important subject to this one reply of mine: It is this very separation of the chaff from the wheat, which is the very essence and value of the English patent system. Rotten patents fall through. But who shall say what is rotten and unsound in invention without this test? Bad patents die a natural death. Is this any reason why they should be murdered, and so, sometimes, a good life be taken.—I am, &c., W. RIDDLE.

South Lambeth, May 3, 1864.

Notes.

PROPOSED GALLERIES AT SOUTH KENSINGTON.—The Commissioners appointed to award the premiums for the designs submitted in competition for the galleries met on the 29th April for their final decision. Present:—Lord Elcho, in the chair, Mr. Tite, Mr. Roberts, Mr. Fergusson, and Mr. Pennethorne. After further examination and discussion, they awarded the first premium to the design distinguished by the motto, "*Ad ogni uccello il suo nido é bello*;" the second to that marked "To build well," &c.; and the third to that inscribed "*Pro Rege et Lege*." This report having been forwarded to the Chief Commissioner of Works, the Right Hon. W. Cowper, M.P., and the letters opened, it was ascertained that the first premium of £400 had been awarded to Captain Fowke, R.E.; the second, of £250, to Professor Kerr; and the third, £150, to Mr. Borthwick. The decisions are stated to have been unanimous.

MEETINGS FOR THE ENSUING WEEK.

MON. ...R. Geographical, 8½. Senor Cox, "On the Physical Geography of the region between Valdivia and La Plata, and on a newly discovered low pass across the Andes." Translated and communicated by Sir Woodbine Parish, F.R.S.
Royal Inst., 2. General Monthly Meeting.

TUES. ...Medical and Chirurgical, 8½.
Civil Engineers, 8. M. Pernolet, "On the means of Utilising the Products of the Distillation of Coal, so as to Reduce the Price of Coke; with Descriptions of the Ovens, and of the Best Processes used in Great Britain and on the Continent in the Manufacture of Coke."
Zoological, 9.
Syro-Egyptian, 7½. Mr. Joseph Bonomi, "On the Alabaster Sarcophagus in the Museum of Sir John Soane."
Ethnological, 8. 1. Mr. John Crawfurd, F.R.S., "On the supposed Stone, Bronze, and Iron Ages of Society." 2. Dr. Donovan, "On Empirical and Scientific Physiognomy as applied to Study of Races of Man and Individuals."
Royal Inst., 3. Professor Marshall, "On Animal Life."

WED....Society of Arts, 8. Mr. J. Bailey Denton, "On the Economy of Agricultural Cottages, considered with regard to the Interests, the Position, and the Duties of the Labourer, the Tenant-farmer, and the Land-owner."
Geological, 8. 1. Mr. T. Codrington, "On a Section with Mammalian Remains near Thame." 2. Mr. E. Witchell, "On a Deposit at Stroud, containing Flint Implements." 3. Major J. Austin, "On the Earthquake which occurred in England on October 6th, 1863." 4. Mr. Arthur Lennox, "On the White Limestone of Jamaica, and its associated intrusive Rocks."
Graphic, 8.
Microscopical, 8.
Literary Fund, 3.
Archæological Assoc., 4½. Annual Meeting.
College of Preceptors, 7½. Dr. W. B. Hodgson, F.C.P., "On the Report of the Commissioners appointed to Inquire into the Condition of the Public Schools."

THUR. ...Royal, 8½.
R. Society Club, 6.
Antiquaries, 8.
Royal Inst., 3. Mr. John Hullah, "On Music (1600—1750)."
FRI.......Astronomical, 8.
Royal Inst., 8. Mr. J. Scott Russell, "On the Mechanical Use of Gun Cotton."
SAT ......R. Botanic, 3¾.
Royal Inst., 3. Prof. Frankland, "On the Metallic Elements."

PARLIAMENTARY REPORTS.

Par. Numb.

SESSION 1863.

431. (A x). Poor Rates and Pauperism—Return (A).

Delivered on April 13, 1864.

141. Railway Companies' Powers—Report and Evidence.
136. Felon's Property—Returns.
162. Watch Cases and Watches—Returns.
167. Private Bills (Petitions, &c., 1864)—Return.
181. National Education (Ireland)—Correspondence.

Delivered on April 14, 1864.

144. Malta Dock—Papers and Correspondence.
180. Poor Law (Ireland) (Kells Union)—Return.
60. Bill—Thames Conservancy.

Delivered on April 15, 1864.

19. Railway and Canal, &c., Bills (267. London, Brighton, and South Coast Railway (Steamboats); 268. London, Chatham, and Dover Railway (No. 3) (Steamboats); 269. Manchester, Sheffield, and Lincolnshire Railway (Steamboats); 270. Mersey Docks and Harbour Board; 271. Portpatrick Railway (Steamboats)—Board of Trade Reports.
42. (1). Banda and Kirwee Booty—Further Return.
78. (1). Lighthouses (Isle of Man)—Supplementary Return.
149. Electors—Return.
185. Public Income and Expenditure—Account.
193. Judgments (Courts of Common Law)—Return.
196. Foreign Bills of Exchange—Return.
169. Increase and Diminution (Public Offices)—Abstract of Accounts.
61. Bills—Church Building and New Parishes Acts Amendment.
62. — Joint Stock Companies (Voting Papers).

Delivered on 16th and 18th April, 1864.

19. Railway and Canal, &c. Bills (272. Metropolitan District Railway (No. 2); 273. Metropolitan Grand Union Railway (No. 2); 274. Tottenham and Hampstead Junction Railway; 275. Wallasey Improvement)—Board of Trade Reports.
55 (3). Railway and Canal Bills—Fourth Report from Committee.
184. Private Bills (Statement of Fees, &c. 1863)—Returns.
193. Savings Banks—Paper.
194. Queen's College (Cork)—Return.
197. Cathedrals—Return.
198. East India (Civil Serviee)—Return.
174. East India (Waste Lands)—Return.
166. Hainault Forest—Return.
67. Bills—High Court of Bombay.
61. ,, Partnership Law Amendment.
69. ,, Court of Chancery (Despatch of Business).
70. ,, Bridges (Ireland).

Delivered on 19th April, 1864.

80 (1). Coal—Copy of Mr. Miller's Letter.
171. Treasury Chest (1862-63)—Account.
179. Convent Schools (Ireland)—Return.
199. Shipping—Return.
66. Bill—Civil Bill Courts (Ireland) (amended).

Delivered on April 20th, 1864.

55 (4). Railway and Canal Bills—Fifth Report from Committee.
152. Holyhead Harbour—Returns.
182. Lisburn Election Petition—Minutes of Proceedings of Committee.
207. Dwelling Houses and Horses (Ireland)—Return.
209. Property and Income Tax—Return.
103 (4). Civil Services—Estimates (Class 4).

Delivered on April 21st, 1864.

19. Railway and Canal, &c., Bills (276. London and North Western Railway (Traffic Arrangements); 277. Lynn and Sutton Bridge Railway (Cross Keys Bridge), (Transfer)—Board of Trade Reports.
35. Revenue Departments—Accounts.
195. Government Houses, &c.—Returns.

Patents.

From Commissioners of Patents Journal, April 29th.

GRANTS OF PROVISIONAL PROTECTION.

Animal and vegetable substances, preservation of—713—J. Morgan.
Animals, preparing the carcases of, for curing—876—J. S. Richardson.
Boots and shoes, stamping, &c., parts of—918—A. J. Fraser and F. Squire.
Bricks, &c., manufacture of—933—T. R. Crampton.
Buckles—884—J. B. Fenby.
Buttons, &c.—922—H. Charles.
Chaff-cutting machine—924—J. C. Rohrbeck.
Cloths, manufacture of—878—D. Moseley.
Coal cellar holes, securing the lids of—920—H. and J. W. Lea.
Compasses—781—W. Arthur.
Dead bodies, embalming and mummifying—926—A. Audigier.
Engines, motive-power—227—J. Young and A. C. Kirk.
Fibrous substances, apparatus for combing—906—M. Todd.
Fire-arms, breech-loading—866—W. Hill.
Fire-resisting materials, application of—841—S. Martin.
Grain, apparatus for washing, &c.—901—T. G. Miller.
Gun carriages, checking the recoil of—880—C. A. Ferguson, jun., and T. Ferguson.
Guns, working of—823—J. Walker.
Iron, &c., compositions to prevent the oxidation of—341—B. Todd
Jute, &c., preparation of, for hackling, &c.—908—J. Ferrier.
Machinery, lubricating—886—R. Thatcher.
Metal plates, hammering and planishing—892—J. Howell.
Metals, apparatus for rolling, &c.—896—J. Dodge.
Minerals, grinding or pulverising—868—C. J. L. Leffler.
Ordnance, &c.—182—T. C. Clarkson.
Pipes, tubes, &c., joints for—354—W. Hawthorn.
Ploughs—916—J. B. Alliott.
Powder flasks, construction of—910—F. A. P. Pigou.
Railway brakes—693—F. Dancart.
Railways and tramways, construction of—577—H. Greaves.
Ships, &c., apparatus for steering—3222—F. H. Fitz William.
Ships, &c., propelling, navigating, &c.—89—W. Welch.
Ships, preserving the bottoms of—928—J. C. Evans and J. C. Thompson.
Small arms and ordnance, sights for—883—F. C. Goodwin.
Spirituous liquors, &c., purification, &c., of—791—T. J. Smith.
Steam, apparatus for condensing—904—W. E. Gedge.
Steam boilers, apparatus for cleaning tubular—872—H. A. Bonneville.
Steam boilers, furnaces for—902—A. T. Becks.
Steam ploughing—934—J. Cope.
Strands, apparatus for covering—890—M. Simpson.
Vessels, apparatus for propelling—874—A. Rigg, jun.
Wire, gold and silver—898—B. X. Richard and R. Radisson.
Wood, ivory, &c., cutting, shaping, &c.—888—T. S. Martin.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Locomotives, adhesion of driving wheels to rails—1046—Sir C. Fox.
Metallic nuts, machinery for manufacturing—966—G. Haseltine.
Nail-cutting machine—1048—F. Bush.
Presses—978—G. T. Bousfield.

PATENTS SEALED.

2718. S. Bateman.	2743. J. Whitworth.
2723. P. A. Sautreuil.	2755. C. H. Southall and R. Heap.
2724. G. Ville.	2783. G. T. Bousfield.
2725. J. Thomas.	2799. J. Smith.
2726. E. Hughes.	2821. G. H. Brockbank.
2727. E. Howe, jun.	120. D. A. Burr.
2729. R. Brooks and C. Inwards.	141. D. A. Burr.

From Commissioners of Patents Journal, May 3rd.

PATENTS SEALED.

2740. B. Blackburn.	2794. J. Mash.
2753. J. Muckart.	2796. S. Faulkner.
2758. J. Townsend.	2832. W. F. Dearlove.
2759. W. M. Neilson.	2838. M. A. Muir & J. McIlwham
2763. R. Johnson.	2886. W. Williams.
2764. W. E. Newton.	2906. R. Walker, J. S. Walker, and B. Brown.
2765. H. L. Emery.	2930. H. Ayckbourn.
2768. J. K. Hoyt.	2945. J. Smith.
2769. J. Johnson.	2946. E. B. Wilson and J. Imray.
2774. A. Prince.	2956. J. H. Johnson.
2775. A. Barclay and A. Morton.	2961. P. Tait.
2780. A. A. L. P. Cochrane.	2981. F. Page.
2782. W. J. Cunningham and H. Connop.	2989. P. Gaskell.
2784. N. Thompson.	3168. H. Chadwick and J. Clench.
2791. S. J. Bartlett.	8. W. Allen and W. Johnson.
2792. H. A. Bonneville.	18. W. Hall.

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

1060. J. Poole and W. Milward.	1304. W. E. Newton.
1064. T. W. Miller.	1075. W. Johnson.
1107. W. Clissold.	1190. J. F. L. Baddeley.
1179. I. M. Singer.	1221. R. Hornsby, jun.
1295. T. Aveling and H. Rawlinson.	

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

1200. D. Chadwick and H. Frost.	1218. S. Mortimer.

Registered Designs.

Butter Dish—4631—April 30—Thos. Geo. Webb, Manchester.
Butter Dish—4632—April 30—Thos. Geo. Webb, Manchester.